American Society of Limnology and Oceanography

Whitman College

Dissertations Initiative for the Advancement of Limnology and Oceanography

DIALOG II

Abstracts of Ph.D. Dissertations Completed between September 1, 1994 - March 31, 1997

Sponsored by:

European Commission
Marine Science & Technology (MAST III) Program

U.S. National Aeronautics and Space Administration
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The Dissertations Initiative for the Advancement of Limnology and Oceanography (DIALOG) program was developed in response to the success of the Dissertations Symposium in Chemical Oceanography (DISCO) program, originally conceived by Edward D. Goldberg. Using the DISCO program as a model, members of the DIALOG Steering Committee developed a program to foster interdisciplinary thinking and collaborative interactions among biologically centered limnologists and oceanographers. While aquatic scientists of all disciplines are encouraged to apply, biology is the common element that unites this effort.

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please contact:

C. Susan Weiler
ASLO Office
Whitman College, Walla Walla, WA 99362
509-527-5948 weiler@whitman.edu http://aslo.org/

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C. SUSAN WEILER

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Whitman College
Biology Department
200 Boyer Ave.
Walla Walla, WA 99362

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The Dissertations Initiative for the Advancement of Limnology and Oceanography (DIALOG) was founded in 1994 to facilitate interdisciplinary, inter-institutional and international aquatic science research, understanding and collaborations. The DIALOG II program targets biologically oriented limnologists and oceanographers who completed their last Ph.D. requirement between September 1, 1994 and March 31, 1997. The program objectives are to:

(1) Compile and publish the submitted Ph.D. dissertation abstracts. The compilation provides a concise overview of current research over the range of biologically related aquatic science.

(2) Convene a symposium to facilitate interdisciplinary, interinstitutional, and international understanding and collaborations among participants; and

(3) Develop and maintain a centralized data base for characterization and tracking of recent Ph.D. recipients, to better identify human-resource trends and needs.

This work was supported by ONR Biological and Chemical Oceanography and Molecular Biology programs, and by NASA, NSF, NOAA, and the European Commission.

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INTRODUCTION

The DIALOG Program was founded in order to reduce the historical, institutional and philosophical barriers that limit the exchange of information between limnologists and oceanographers, and to foster interdisciplinary thinking and collaboration. The program targets recent Ph.D. recipients whose work is applicable to biologically oriented limnology or oceanography. Relevant Ph.D. dissertation abstracts are collected and made available in this document and on the ASLO web page (http://aslo.org/), a symposium is held to facilitate collegial relationships across institutions and disciplines, and information is collected to characterize and track program participants.

The first DIALOG program was held in 1994, targeting individuals who completed their last Ph.D. requirement between June 1, 1992 and August 31, 1994. The DIALOG II program targeted individuals completing their Ph.D. requirements between September 1, 1994 and March 31, 1997. A total of 98 dissertation abstracts were received, with 87 individuals applying for the DIALOG II symposium. The 43 symposium participants were selected on the basis of their dissertation abstract, CV, statement of interdisciplinary research interest, and program balance.

Statistical Information - DIALOG Applicants

The DIALOG II application period closed with 203 applications requested;
98 applications completed and returned by the May 1, 1997 deadline; and
87 applications for symposium participation (compared with 137, 80 and 67 in 1994).
Forty-four of the 98 applicants completed their Ph.D.'s at U.S. academic institutions (Table 1). Applicants included:

- **58 (59%) limnologists** (29 females, 29 males)
  40 (41%) oceanographers (22 females, 18 males)
  (compared with 34% limnologists, 66% oceanographers in the DIALOG I Program). The ASLO membership is evenly split between limnologists and oceanographers. Mailings were made to more limnologically oriented societies this year to "correct" for the over-representation of oceanographers last time. More oceanographic societies will be added next time to strive for a 50/50 balance.

- **51 (52%) females**
  47 (48%) males
  (compared with 34% female, 66% male in the DIALIG I Program). The increase in female representation is consistent with demographic trends in graduate schools and in the ASLO membership.

- **37 (38%) U.S. citizens** (19 female, 18 male) of which 18 were limnologists (8 female, 10 male) and 19 were oceanographers (11 female, 8 male). Three were under-represented minorities.
  61 (62%) citizens of 26 other countries (13 German; 6 Canadian; 6 Indian; 6 Chinese; 5 Russian; 2 Egyptian; 2 Pakistani; 2 Brazilian; 2 Spanish; 1 Argentinean; 1 Belgian; 1 British; 1 Dutch; 1 Ethiopian, 1 French; 1 Greek; 1 Irish; 1 Israeli; 1 Japanese; 1 Nepalese; 1 Nigerian; 1 Polish; 1 Swedish; 1 Ukrainian; 1 Venezuelan; 1 Zimbabwean).

- **The median age of all participants was 33** (range: 26 - 49). The median age of the 37 American participants was 33 (range: 27 - 49), with females ranging from 28 - 49 years (median 33) and males ranging from 27 - 46 (median 32).

Statistical Information - DIALOG Symposium Participants

The DIALOG II symposium brought together 43 recent graduates for the purpose of catalyzing inter-disciplinary and interinstitutional research and interactions. The selection committee (Stephen Baines, Samantha Joye, James Kitchell, Hans Paerl, Deborah Penry and Saran Twombly) read and evaluated all applications and met for two days to select participants. With 87 excellent applicants from 23 different countries and only 43 positions, the choice was not easy. Selection was based on the application materials, which included a brief CV, dissertation abstract, essays on interdisciplinary interests and professional goals, letters of recommendation, and program balance. Several invitees were unable to attend, resulting in a final acceptance rate for the symposium of 55%.

- **15 nationalities**: 27 Americans (14 female, 13 male; 12 limnologists and 15 oceanographers); 5 German; 3 Canadians; 2 Chinese; 1 Brazilian; 1 British; 1 Dutch; 1 Ethiopian; 1 Indian; 1 Irish; 1 Israeli; 1 Polish; 1 Swedish; 1 Ukrainian; and 1 Zimbabwean.

- **25 limnologists and 23 oceanographers**

- **26 females and 22 males**

Funding for international participation was made possible through a grant from the European Commission and through travel awards from Biospherical Instruments and Turner Designs.

DIALOG Program Follow-On

Recent Ph.D. recipients may register their dissertation at any time on the ASLO web page (http://aslo.org/dialog2a.html). Citations of all dissertations registered via the web page will be published in the *ASLO Bulletin* and, contingent on the availability of funds, citations and abstracts will be posted on the ASLO web page.

Contingent on obtaining external funding, a DIALOG III program is planned with a symposium to be held in October, 1999.

TABLE I. Institutions granting Ph.D. degrees to DIALOG II program applicants. Numbers refer to the number of applicants with degrees from the institution. Dissertation fields are listed as lim (limnology) or oce (oceanography), based on students' primary area of dissertation research.

Lim	Oce	U.S. Institutions
0	1	College of William and Mary
1	0	Cornell University
0	1	Duke University
1	0	Kent State University
0	2	Louisiana State University
0	1	Massachusetts Institute of Technology
1	0	Michigan State University
2	0	Michigan Technological University
0	1	Northeastern University
1	0	Ohio State University
0	1	Stanford University
0	3	State University of New York at Stony Brook
1	0	State University of New York, College of Environmental Science & Forestry
0	1	Texas A&M University
1	0	University of Alabama
0	1	University of California at Berkeley
1	1	University of California at Santa Barbara
0	1	University of California at Santa Cruz
1	0	University of Florida
0	1	University of Hawaii
0	1	University of Maryland
0	1	University of Miami
1	0	University of Michigan
2	0	University of Minnesota
1	0	University of North Carolina at Chapel Hill
0	1	University of Pittsburgh
0	1	University of Rhode Island
0	3	University of Southern California
0	1	University of Southern Mississippi
0	1	University of Tennessee
0	2	University of Washington
2	0	University of Wisconsin at Madison
1	0	University of Wisconsin at Milwaukee
1	0	Virginia Polytechnic Institute & Virginia State University at Blacksburg

Lim	Oce	Non-U.S. Institutions
1	0	Aristotle University of Thessaloniki (Greece)
0	1	Autonomous University of Barcelona (Spain)
1	0	Bar-Ilan University (Israel)
1	0	Banyero University (Nigeria)
1	0	Central University of Venezuela (Venezuela)
1	0	Christian Albrechts University (Germany)
2	0	Dalhousie University (Canada)
1	0	Federal University of Rio de Janeiro (Brazil)
3	0	Irkutsk State University (Russia)
0	1	Kyushu University (Japan)
1	0	Lodz University (Poland)
1	0	Louis Pasteur University (France)
1	0	Ludwig Maximillian University (Germany)
1	0	Lund University (Sweden)
1	0	Max Planck Institute for Limnology at Ploen (Germany)
0	1	Memorial University of Newfoundland (Canada)
1	0	National Amazonian Fisheries Institute (Brazil)
1	0	Queen's University (Canada)
3	0	University of St. Petersburg (Russia)
0	1	Stockholm University (Sweden)
1	0	Ukrainian National Academy of Sciences (Ukraine)
1	0	United Universities of Parma, Ferrara, Bologna and Roma (Italy)
1	0	University of Aberdeen (Scotland)
1	0	University of Agriculture, Forestry and Renewable Natural Resources at Vienna (Austria)
1	0	University of Alberta (Canada)
0	1	University of Alexandria (Egypt)
0	1	University of Bremen (Germany)
1	0	University of Buckingham (U.K.)
1	0	University of Buenos Aires (Argentina)
1	0	University of Calcicut (India)
1	0	University of Constanz (Germany)
2	0	University of Delhi (India)
1	0	University of Geneva (Switzerland)
0	1	University of Groningen (The Netherlands)
1	1	University of Hamburg (Germany)
1	0	University of Kerela (India)
1	0	University of Kiel (Germany)
1	0	University of London (United Kingdom)
1	0	University of Ottawa (Canada)
1	0	University of Quebec (Canada)
0	1	University of Rostock (Germany)
0	1	University of Technology at Dresden (Germany)
1	0	University of Valencia (Spain)
1	0	University of Victoria (Canada)
2	0	Uppsala University (Sweden)
0	1	Ziamen University (China)

Register dissertations on the ASLO web page:

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98 **Zubina, Larisa V.** 1995. Peculiarities of oogenesis and reproductive cycle in ecologically different species of Baikalian cottid fishes (Cottidae, Abyssocottidae). Russian Academy of Sciences at St. Petersburg (Russia), 199 pp.

An Environmental Impact Assessment of Pollution on the Arabian Gulf

Ahmed, Mahmoud H. M. 1997
Alexandria University (Egypt), 218 pp.

The marine environment of the Arabian Gulf is becoming increasingly important in fulfilling social, economic, development and strategic objectives of the region. The gulf area is subjected to intensive and diverse human activities including: oil production, industry, air pollution,urban developments, and coastal activities. Human interventions have resulted in a series of direct and indirect impacts that now threaten the gulf ecosystem. The objective of this study was to define and quantify related and unrelated impacts of the 1991 Gulf War on the gulf marine environments in a trial to evaluate the effective assessment and management of the gulf resources. This attempt was achieved by carrying out spatial distribution of sequential extraction of heavy metals in the surfacial bottom sediments of the Arabian Gulf; and studying the environmental processes deriving and controlling lithofacies sediment groups (texture analyses, total aromatic hydrocarbons, organic matter content, and total carbonate). Results obtained have been used to assess short and long-term impacts of different pollutants on the marine and coastal ecosystems of the Arabian Gulf.

Eighty-four surface sediment samples were collected during LEG I of NOAA R/V MT.Mitchell cruise through February 1992, covering the entire gulf area using a Smith MacIntyre grab sampler. The investigated stations were geographically distributed along 15 cross-shore transects. Each individual sample was treated separately for determining the texture analysis, total organic carbon content, total aromatic hydrocarbon, and total carbonate content. An analytical procedure in sequential extraction of heavy metals has been used to study the different extracted phases of heavy metals Fe, Mn, Co, Cu, Zn, Ni, Cr and Pb. The use of sequential extraction procedures provide qualitative information that may allow the prediction of the biological availability, mobilization, and transport of heavy metals.

Mapping of mean grain size, carbonate content, total aromatic hydrocarbon (TAHC) and organic matter revealed distinguished distribution pattern. The most conspicuous change in carbonate content and organic matter occurs within the northern and southern parts of the gulf. The geographical distributions of the TAHC revealed low concentrations covering most of the study area. Only two high concentration batches were noticed between the Iranian and Arabian near shore areas reaching a very high concentration of about >100 micrograms per gram. The behavior of heavy metals concentrations levels in bottom sediments of the Arabian Gulf clearly indicated the difficulty of distinguishing between background and anomalous levels of heavy metal analysis. Factor and cluster analyses applications revealed that metals accumulation in gulf sediments proved to be strongly affected by the environmental controlling variables.

Multidata (geological, physical, chemical, biologica,l and socioeconomic) were analysed to identify and predict the environmental-related consequences resulted from main human intervention as well as from the oil spill of 1991 Gulf War. An interaction impact matrix (human activities versus environmental attributes) was constructed to identify and evaluate possible impacts, magnitude and importance on the marine and coastal ecosystem of the Arabian Gulf region.

Application of Nutrient Enrichment Bioassays to Evaluate Spatial and Temporal Limiting-Nutrient Patterns and to Estimate Surplus Phosphorus Concentrations in Lake Okeechobee, Florida

Aldridge, Frederick J. 1994
University of Florida (USA), 101pp.

Nutrient enrichment bioassays (NEB) were used to assess the spatial and temporal distribution of nitrogen (N) and phosphorus (P) limitation of phytoplankton biomass and to estimate surplus P in Lake Okeechobee, Florida. Results of three years (1990-92) of monthly assays on samples collected from five stations showed that N was the dominant limiting nutrient. The second most common result was a lack of limitation by either N or P indicating that there was a surplus of both nutrients available for phytoplankton growth. Phosphorus was never a primary limiting nutrient although N and P co-limitation occurred.

Frequency analysis of limiting nutrient classifications showed both spatial and temporal organization to the type and frequency of limiting factors. Limiting nutrient classifications were matched with physical and chemical data to define discriminant functions for N, NP co-limited and nutrient-unlimited conditions. Discriminant functions were applied to a larger physical and chemical data set collected from 76 stations over a three-year period to develop maps of spatial and temporal distribution of limiting nutrient classifications. Nitrogen was predicted to be the primary limiting nutrient from the lake shore to the three-meter depth contour for all seasons. In areas deeper than three meters it was predicted that phytoplankton growth is unlimited by nutrient availability in all but the summer months when N was limiting.

Estimates of surplus P were determined from direct chemical measurements and the phytoplankton biomass (as chlorophyll-A) supportable by surplus P was determined using NEB. There was a significant relationship between surplus P and supported chlorophyll-A (chl-A). The average surplus P and supported chl-A at the 5 stations ranged from 13 to 55 milligrams (mg) per cubic meter with an overall averages of 31 and 32 mg per cubic meter respectively. Both variables were highest at the north and central stations and lowest at the south and southwest stations. Approximately 50% of total P was in the form of surplus P and not expressed as phytoplankton biomass. Quantifying the surplus P in a lake provides a direct estimate of the amount of P that must be reduced before phytoplankton standing crop will be nutrient limited by P.

Nutrient enrichment bioassays were found to provide a method to test empirical relationships and to identify factors that can confound standard empirical models of the relationship between phytoplankton and nutrients.

Rate and Mechanistic Controls on Stable Isotopic Composition of Biogenic Methane in Wetland Environments

Avery, G. Brooks Jr. 1996
University of North Carolina at Chapel Hill (USA), 132 pp.

The stable isotopic composition of biogenic methane fluxes from wetland environments may provide important constraints on their role in the global methane budget. However, the causes of observed spatial and temporal variations in delta (del) 13C values are not well understood. The controls on these del 13C values were investigated through field and laboratory experiments. Isotopic shifts associated with methane production could result from changes in: (1) isotopic compositions of the precursors, (2) kinetic isotope effects associated with methane production, (3) pathways of methane production. The purpose of this study was to use rate and isotopic data from incubation experiments employing natural soils and sediments from two contrasting wetlands in North Carolina and Michigan to determine the causes of observed natural variations. Methodologies used to determine rates and pathways in wetlands were critically assessed. Methane produced in sediments from a tidal freshwater estuary site in North Carolina, exhibited relatively small changes in del 13C values throughout the year, ~3 per thousand (mil), with 13C-enrichment occurring during warmer months (winter = -69.2 per mil; summer = -66.1 per mil). The majority (84 +/- 22%) of this seasonal isotopic variation could be attributed to changes in the del 13C value of the sum CO2 pool and the kinetic isotope effect associated with methane production from CO2. A Michigan peatland also displayed 13C-enrichment in methane produced during the warmer months (+11 per mil). This isotopic shift resulted from significant changes in pathways of methane production. The del 13C value of methane from CO2 reduction (-71.4 +/- 1.8 per mil) was depleted in 13C compared to methane produced from acetate (-29.3 +/- 24.4 per mil). Tracer experiments utilizing 14C-labeled substrates indicated that during January, 94 +/- 20% of the methane was produced by CO2 reduction. However, as the sediments warmed during the spring, rates of aceticlastic methanogenesis approached those of CO2 reduction. At both sites, the del 13C values of methane produced during warmer months were enriched in 13C. Small seasonal variations (~ 3-6 per mil) in the del 13C values of biogenic methane from wetlands can result from changes in the del 13C values of substrates. However, larger variations (10 per mil or more) appear to be a result of significant shifts in the balance of production mechanisms.

Plankton Development and Trophic Interactions in Rivers

Basu, Ben K. 1997
University of Ottawa (Canada), 212 pp.

The factors regulating the development and trophic interactions of planktonic communities were determined in 31 temperate rivers. In addition, the Rideau River, Ontario was studied in detail over three seasons. Variables measured included: phytoplankton biomass as measured by chlorophyll-A (chl-A), zooplankton biomass, heterotrophic bacterial and flagellate abundance, nutrient concentrations (phosphorus and nitrogen), dissolved organic carbon concentration, discharge, water residence time, depth, temperature, and light attenuation.

Phytoplankton was abundant in eutrophic rivers (> 15 micrograms per liter of chl-A) and was most strongly related to nutrients, primarily total phosphorus (TP) which explained up to 76% of the variation in chl-A. Phytoplankton biomass in the rivers was not related to the hydrological parameters of water residence time or discharge, possibly due to the short generation time of phytoplankton. Light did not appear to limit phytoplankton biomass due to shallow depths and extensive vertical mixing of the water columns. In the Rideau phytoplankton biomass exhibited longitudinal heterogeneity, but in general increased downstream, concomitant with increases in nutrients. Phytoplankton biomass did not appear to be affected by zooplankton grazing in the rivers. However, phytoplankton may have been negatively impacted by benthic filter feeders, in particular the invasive zebra mussel (DREISSENA POLYMORPHA), in the downstream reaches of the Rideau River.

Zooplankton biomass in the rivers was low (usually < 20 micrograms per liter dry mass) and small taxa dominated the zooplankton communities (rotifers, bosminids). Large zooplankton taxa, such as DAPHNIA sp., were much less abundant. Due to longer generation times, zooplankton biomass was primarily related to water residence time which explained 33% of the variation. Zooplankton appeared susceptible to advective loss in the rivers. A positive resource effect of either nutrients or phytoplankton on zooplankton biomass, typically observed in lakes, was weaker in the rivers. In comparison to lakes, zooplankton appeared less tightly coupled to phytoplankton. As with phytoplankton, zooplankton biomass in the Rideau increased downstream and appeared to be negatively affected by benthic filter feeders.

Heterotrophic bacteria were abundant in the rivers (4.5 million cells per milliliter) and as in lakes, bacteria were most strongly related to nutrients (TP) and chl-A. In contrast to lakes, no relationship between river bacterial abundance and dissolved organic carbon was observed, possibly due to the more allochthonous, refractory nature of river dissolved organic carbon. Heterotrophic flagellates were also abundant (4.0 thousand cells per ml) and were most strongly related to bacterial abundance and nutrients (TP). Neither bacterial nor flagellate abundance was related to water residence time. A negative relationship between zooplankton biomass and bacterial or flagellate abundance was not observed, possibly because of the low grazing pressure of zooplankton in the rivers. Due to the scarcity of zooplankton in rivers, there may be little transfer of energy from the planktonic microbial food web to planktonic metazoans.

Inorganic Carbon Availability for Dinoflagellate Photosynthesis in Lake Kinneret, Israel

Berman-Frank, Ilana R. 1996
Bar-Ilan University (Israel), 162 pp.

In most oceanic and in many fresh-water systems, aqueous (aq) carbon dioxide (CO2) constitutes a small fraction of the total inorganic carbon (C1). Although substantial research has focused on CO2 limitation, and adaptive C1 uptake mechanisms in a few test organisms, the ecological importance of CO2 limitation on dominant phytoplankton in their natural environment has received relatively little attention. The above statement also holds true for Lake Kinneret (Israel). Particularly intriguing is the possible role of CO2 limitation in determining species succession in the lake, especially during the annual bloom of the dinoflagellate, PERIDINIUM GATUNENSE, responsible for over 60% overall primary production in Lake Kinneret. The objectives of this study were: (1) to characterize the C1 uptake mechanisms in P.GATUNENSE; (2) to follow changes in carbonate chemistry of the lake during the P.GATUNENSE bloom, and to examine the role of CO2 availability as a factor influencing the bloom dynamics and species composition.

The response of natural populations of P. GATUNENSE to changes with time in the concentration of C1 in Lake Kinneret subsurface water was recorded by examining seasonal fluctuations in the activity of CA and in photosynthetic parameters. Distinct fluctuations of both external and cytoplasmic CA activity were observed in P. GATUNENSE throughout the annual bloom. Higher levels of activity were triggered by the decline of C1 below 1.8 milliM and more specifically by low concentrations of dissolved CO2 (aq) (1-10 microM) found during the bloom decline in May-June. Predicted rates of photosynthesis from uncatalysed dehydration of HCO3 and CO2 diffusion, showed that only at the beginning of the bloom can CO2 (aq) concentrations support photosynthesis based on diffusion only. Decreased CO2 concentrations caused P. GATUNENSE to also activate a carbon-concentrating mechanism (CCM). The fractionation of delta 13C decreased with the progression of the bloom from ~ -23 parts per thousand to -17 parts per thousand. Eventually, cellular adaptations of P. GATUNENSE to the declining CO2 concentrations could not prevent decline of photosynthetic rates contributing to the subsequent decrease in P. GATUNENSE biomass in May-June. Lake Kinneret P. GATUNENSE is succeeded by PERIDINIOPSIS spp., the photosynthetic rates and external CA activities of which were much higher under environmental conditions typical of the end of the bloom. Analysis of multi-year data from the lake suggests that CO2 (aq) concentrations, in addition to other limiting parameters, are influential in determining in situ growth rates and eventually biomass accumulation. This study provides an example of a medium-sized natural lake ecosystem in which C1 availability is one of the factors limiting phytoplankton photosynthetic rates and, indirectly influencing algal species composition. The questions of whether oceanic primary production is CO2-limited and the effects of increasing atmospheric CO2 on phytoplankton remain controversial. Our findings suggest that in systems similar to Lake Kinneret increasing atmospheric CO2 concentrations may enhance primary productivity and growth rates, stimulating further sequestering of atmospheric CO2.

Vegetation and Climate of Prebaikalie in the Late Glacial and Holocene

Bezrukova, Elena V. 1996
Russian Academy of Science at Irkutsk (Russia), 199 pp.

One of the most important tasks of contemporary natural sciences is reliable prediction of the climate of the nearest future. Many of cores of Baikal sediments are obtained for paleoclimate reconstructions in the frame of different projects. Palynological investigations provide us with valuable information about paleoclimates. It is known vegetation most depends on climate. Moreover study of the last geological period of time, Holocene, gives us the opportunity to realise the way of vegetational and climatic changes. The results of palynological investigations of 8 cores from Lake Baikal sediments are presented in my dissertation. Besides palynology these sediments provided results on diatom algae analysis, biogenic silica and radiocarbon ages. The results of palynological, paleocarpological and radiocarbon analysis of 8 cores of peatbog sediments which are placed on Baikal Lake shore are also shown in the dissertation. The basis for interpretation of fossil SPS are 155 subrecent SPS obtained from 0.5-1 centimeter of upper layer of sediments of different genesis. The palynological results of subrecent SPS are pictured on "TILIA" computer programme. Isopoll maps of many genera of plants and schememaps of modern climate gradients distribution are also pictured on "TILIA" programme. The comparison of these two datasets allow to obtain information about climate conditions of plant existing.

The results of palynological investigations of Holocene sediments of Prebaikalie provided some important conclusions:

1) Six large-scale stages of development of climate and vegetation of Prebaikalie are picked out within last 15 thousand years. They have geochronological boundaries.
2) Isolation and getting up of two main present day existing vegetation complexes, dark coniferous and light coniferous forests, occurred within middle-late Holocene.
3) The period between 6,5-8 thousand years ago was Holocene optimum time when wet dark coniferous forests "taiga" of ABIES SIBIRICA were widespread.

Microbial Enzymatic Degradation of Organic Matter in Deep-Sea Sediments

Boetius, Antje 1996
University of Bremen (Germany), 197 pp.

Several investigations on the biology of deep-sea microorganisms showed that their comparatively low activity is mainly caused by the limited availability of degradable organic matter rather than by the high pressure and low temperature which is characteristic of the abyssal environment. Yet, in deep-sea sediments, bacteria occur in high numbers and account for most of the biological turnover of elements. Evidence of their impact was found to depths of 500 meters below the sediment surface, indicating that some of the bacterial populations are efficiently adapted to extreme oligotrophy. Likely, the critical step in the nutrition of deep-sea bacteria is the breakdown of refractory polymeric substances by extracellular enzymes, since only small molecules can pass through the cell membrane. Therefore, to study the adaptation of natural microbial assemblages to life under severe nutrient limitation, this investigation focused on microbial degradative potentials in deep-sea sediments of different trophic status and on the factors regulating the activities of several of their extracellular enzymes.

Strong trophic gradients can be found downward continental slopes, since the supply with particulate organic matter decreases largely with distance from the productive coastal areas and with increasing water depth. Concentrations of different organic compounds as well as microbial biomass and enzymatic activities were measured along several transects down the Mediterranean and the Arctic continental slope, representative of warm (>10 degrees C) and cold deep-sea environments (<2 deg C), respectively. The enzymatic potentials of the bacterial assemblages changed substantially in quantity and quality with increasing oligotrophy of their environment. The activity of several carbohydrate degrading enzymes was strongly correlated with variables indicating food availability as well as with oxygen consumption in the sediments, decreasing substantially down the continental slope. Enrichment experiments indicated that these enzymes are regulated by substrate induction, allowing effective utilization of incoming pulses of particulate organic matter (POM). In contrast, the activity of protein degrading enzymes was severalfold lower at the shelf edge compared to the oligotrophic open ocean sediments. This is likely due to negative regulatory mechanisms repressing enzyme synthesis when adequate substrates are available, to prevent excess energy expenses of the cells. The results of several enrichment experiments suggested that bacterial assemblages are able to adapt their degradative potentials to food pulses of different quality within days. Furthermore, the composition of the POM available to the bacterial assemblages in deep-sea sediments has substantial effects on the hydrolysis rates and the assimilation efficiencies of the cells and thus on the recycling of organic carbon and nitrogen.

Daphnia Swimming Behavior and Its Role in Predator-Prey Interactions

Brewer, Matthew C. 1996
University of Wisconsin at Milwaukee (USA), 155 pp.

Ecosystems are characterized by their storage and transfer of nutrients and energy. Therefore, understanding ecosystems requires an understanding of the functional role of each of its members. The water flea DAPHNIA occupies a central position in freshwater ecosystems, transferring energy and organic matter from primary producers (algae) to higher consumers (invertebrates and fish). Since swimming behavior affects DAPHNIA's ability to find food and avoid predation, it is a vital part of DAPHNIA's ecology. In this thesis, I investigate the role swimming behavior plays in structuring DAPHNIA's functional role in aquatic ecosystems.

I investigated the ability of DAPHNIA to alter its swimming behavior in response to changes in temperature, food concentration and light intensity using two scale-independent measures, the fractal dimension and the integrated turning angle. Of the two measures, the integrated turning angle was the most diagnostic measure, revealing several differences among treatments. The differences among treatments indicate that DAPHNIA indeed alter their swimming behavior in response to different environmental conditions.

I devised the Virtual Plankton system to test the hypothesis that small-scale zooplankton swimming behaviors affect DAPHNIA predation risk. By observing fish "preying" on computer-generated prey images whose movement was precisely controlled, I found that fish preferentially choose individuals that hop faster than neighbors. This indicates that small-scale swimming behavior, by increasing conspicuousness, plays an important part in determining DAPHNIA's overall vulnerability to predation.

Finally, I investigated the effectiveness of DAPHNIA escape swimming in four DAPHNIA clones from different predation regimes. The results of simulated and real predation experiments indicate that DAPHNIA's escape response is both efficient and effective in that (1) escape behavior is only enhanced under environmental conditions in which visual predation is a significant threat, i.e. in the presence of both light and predator chemical cues (kairomones), (2) escapes are usually performed only in response to hydromechanical stimuli which are strong enough to signify a potential predator and, (3) under realistic lighting conditions, their escape behavior is sufficient to escape predation from small fish.

Egg Bank Dynamics and Daphnid Species Diversity in Oneida Lake, New York

Caceres, Carla E. 1997
Cornell University (USA), 177 pp.

Understanding the factors that influence diversity is a fundamental objective of ecology. In Oneida Lake, New York, two DAPHNIA species (D. GALEATA mendotae and D. PULICARIA) have persisted for decades or centuries despite the fact that their water-column densities are negatively correlated. One species typically is abundant while the other remains in low numbers. This transient dominance lasts for months or years and has been hypothesized to result from a combination of predation and competition. It raises two questions: (1) how is each species able to persist over the long term; and (2) if there is competition, why are both species present in the system?

Both species produce diapausing eggs that remain viable in the lake sediments for over a century, creating populations with overlapping generations. Theoretical models suggest that overlapping generations, in combination with a temporally fluctuating environment, may allow not only population persistence but also the stable coexistence of competitors. Despite extensive theoretical development, this "storage effect" hypothesis has received little empirical attention. In this dissertation I not only explore the prerequisites of the model but also present the first explicit mathematical analysis of the contribution of the storage effect to the dynamics of competing natural populations.

In studying the community dynamics of two species of the herbivorous zooplankton, DAPHNIA, I have not only demonstrated competition between these two species, but have also shown that both species have a long-lived stage. Moreover, recruitment to this long-lived stage is negatively correlated between species, so that both daphnids have years in which they are favored relative to their competitor. When the long term population growth rates are analyzed both with and without the effects of a variable environment, it is shown that DAPHNIA GALEATA MENDOTAE clearly cannot persist without the storage effect. In contrast, D. PULICARIA persists through consistently high per capita recruitment to the egg bank.

Benthic Macroinvertebrates in Four Amazonian Lotic Ecosystems Influenced by the Activities of a Bauxite Mine (Porto Trombetas, Para, Brasil)

Callisto, Marcos. 1996
Federal University of Rio de Janeiro (Brazil), 140 pp.

Benthic macroinvertebrate communities were studied on igarapes Saraca, Carana, Agua Fria and Trombetas River on Porto Trombetas, Municipality of Oriximina, Para, Brazil (1 degree 25' and 1 deg 35'South and 56 deg 15' and 56 deg 25'West). The main objective was to investigate the taxonomic structure, composition and seasonal dynamic of benthic macroinvertebrates, with emphasis on the occurence and seasonal dynamics of benthic macroinvertebrates. Special attention was given to the occurence and seasonal distribution of Chironomidae (Diptera, Insecta) benthic larvae on rainy (May-June) and dry seasons (October-November) of 1994 and 1995, on three sample stations in each ecosystem, relating with ecological modifications of the activities of a bauxite mine. The highest taxonomic richness organisms (Chironomidae and Oligochaeta) were found on igarape Saraca, in the area affected by the dam. During the rainy season macrobenthic organisms were not found on impacted sample station of igarape Carana on both years, where just few larvae of POLYPEDILUM and CHIRONOMUS were present on dry period. On igarape Agua Fria where the negative influence of the bauxite tailling is increasing gradually, Chaoboridae (Diptera, Insecta) larvae dominated the benthic macrofauna. Moreover it was observed that the degradation of ecological conditions of this ecosystem will probably continue because the transporte of fine particules of clay by the local corrent. On the Trombetas River, discharges of mineral occur accidentally and are deposited on the sediment. The data obtained showed that the mining activities made physical modifications (hydrodinamic changes by the dam formed by construction of a railroad, presence of bauxite tailing and/or bauxite mineral on the sediment, modifying the granulometric composition), chemical modifications (concentrations of available phosphorus, total nitrogen and organic carbon on sediment) and biological modifications (taxonomic structure and distribution of organisms). It was evidenced the possibility of using benthic macroinvertebrates as indicators of ecological conditions of these ecosystems pointing out the temporal (rainy and dry seasons of 1994 and 1995) and spatial changes (natural sample stations and impacted sample stations influenced by the activities of bauxite mining).

Origin and Maintenance of High Nutrient Condition in the Equatorial Pacific: A Biological-Physical Model Study

Chai, Fei. 1995
Duke University (USA), 170 pp.

A physical-biological model was developed for the equatorial Pacific Ocean. It was used to investigate the physical and biological causes for high nutrient condition in the equatorial Pacific. At 0 degree 140 degrees West, nitrate fluxes due to the mixing were small compared to the advective fluxes; vertical transport by the equatorial upwelling and zonal transport in the equatorial undercurrent were the major fluxes. In the equatorial cold tongue, the net physical flux of nitrate to the euphotic layer in carbon (C) units was 15.09 millimole C per square meter per day.

Model experiments showed that iron limitation of phytoplankton is not necessary for maintenance of a high-nutrient plume; that is, the plume of high nitrate water can be generated solely by physics. However, model results indicated that iron limitation determined the concentration level of nitrate in the nutrient-rich plume and created north-south asymmetry in the nutrient fields. Model results also suggested that if the equatorial Pacific Ocean were micronutrient replete, nitrate concentration would be reduced by half from its present value. The zooplankton grazing hypothesis was tested by reducing or enhancing the maximum zooplankton grazing rate. Model results suggested that the ratio of the maximum zooplankton grazing rate to the maximum phytoplankton growth rate should be between 0.5 and 0.75.

Interannual variations in the equatorial Pacific Ocean were simulated. In the model as in nature strong trade winds create the west-east asymmetry of the upper ocean heat and nitrate content which set up the salient zonal characteristics of the basinwide ecosystem in the equatorial Pacific Ocean. A strong El Nino event completely eliminated the basinwide west-east asymmetry, while a La Nina reinforced such asymmetry. The modeling results support the interpretation of Barber (1988) concerning the role of zonal asymmetry in determining the equatorial productivity gradient. The shift-up phenomenon described by MacIsaac et al. (1985) may constrain nitrate concentrations during the overshoot period, which would explain why the model without "shifted-up" rates predicts nitrate concentrations higher than the observed concentrations.

Biological Invasions in the San Francisco Estuary: A Comprehensive Regional Analysis

Cohen, Andrew N. 1996
University of California at Berkeley (USA), 465 pp.

This study describes and analyzes 231 nonindigenous salt water, brackish water, and freshwater species, including plants, protists, and invertebrate and vertebrate animals that have been introduced into the San Francisco Estuary since the 1850's. Data is also provided on nonindigenous species established in tributary waters and adjacent terrestrial habitats, and species reported but not established in the estuary.

The estuary's nonindigenous species derive mainly from the western North Atlantic (33% of marine introductions), the western North Pacific (25%) and the eastern North Atlantic (13%), and from North America (53% of continental introductions, mainly fish) and Eurasia (34%, mainly plants). Since 1970, an average of one new species has become established in the estuary every 15 weeks, more than three times the invasion rate before 1970. Since 1850 the dominant transport mechanisms have been ship fouling, ballast water, oyster shipments, and government activities (mainly fish stocking), with ballast water now dominant. Comparisons with other regional studies of marine and aquatic invasions reveal some common taxonomic patterns.

Invaders in the estuary often occupy habitats upstream of related native species. The rate of successful establishment of intentionally planted fish and shellfish has not changed over time, suggesting that the increased invasion rate may be due to increased numbers of organisms released, rather than to changing conditions making the estuary more vulnerable to invasions. Freshwater and anadromous invaders have been more successful than salt water and catadromous organisms; other traits tested do not correlate significantly with successful establishment. Analysis of the parasite loads of freshwater fish does not support the hypothesis that lower parasite loads enable introduced organisms to become established by outcompeting natives.

The impacts of introduced salt, brackish, and freshwater organisms on human activities and economies have been little studied and rarely quantified. These impacts have been substantial and mainly negative in the estuary. The continuous addition of new species has made the estuary's ecosystem more unstable, less predictable, and increasingly difficult to manage, and is a significant factor leading to increased restrictions on the operation of the California water system--with potential impacts on the whole California economy.

Phytoplankton Responses to Whole-Lake Manipulations of Nutrients and Food Webs

Cottingham, Kathryn L. 1996
University of Wisconsin at Madison (USA), 211 pp.

Phytoplankton are a focal point in management strategies to improve or maintain lake water quality. Although much research has focused on macroscopic phytoplankton attributes such as total biomass and bloom-forming cyanobacteria, more subtle responses may be also be important for trophic relationships and may serve as indicators of ecosystem change. The objectives of this dissertation were to (1) quantify macroscopic and subtle responses of phytoplankton community structure to experimental manipulations of nutrient inputs and food web structure, and (2) determine what phytoplankton variates are reliable indicators of nutrient enrichment.

These objectives were achieved using data from whole-lake experiments conducted in Paul, Peter, West Long, and East Long Lakes (Gogegic County, Michigan) during summers 1991-1994. In May 1991, contrasting food webs were established by manipulating fish communities, then each lake was monitored weekly for two summers under background nutrient conditions. In 1993 and 1994, Peter, West Long, and East Long Lakes were enriched with nitrogen and phosphorus at 5-10 times background rates and at ambient nitrogen:phosphorus (N:P) ratios. Chlorophyll, primary productivity, and phytoplankton species were measured routinely; I created additional phytoplankton variates by aggregating the species data into taxonomic (genera, divisions), allometric (average size, size classes, size spectra) and community variates (diversity, richness, evenness).

I first quantified the effects of the nutrient and food web manipulations on these phytoplankton variates using ARIMA time series analysis. Nutrient enrichment increased cyanobacteria, chlorophytes, cryptomonads, mean size, chlorophyll and primary productivity, but decreased species diversity, chrysophytes and dinoflagellates. Larger zooplankton decreased small phytoplankton and species diversity, but increased large phytoplankton and mean size. Effects of zooplankton on chlorophyll and taxonomic divisions differed among lakes due to differences in species composition and size structure among plankton communities. Overall, the magnitude and direction of nutrient effects on all variates were more consistent among lakes than food web effects, suggesting that phytoplankton responses to nutrient perturbations should be more predictable than responses to food web perturbations. In addition, the effects of both perturbations on allometric variates were more consistent among lakes than effects on taxonomic variates, suggesting that responses of size-based variates to these perturbations should be more predictable than responses of taxonomy-based variates.

I then determined what phytoplankton variates were reliable indicators of the experimental nutrient enrichments using Bayesian time series analysis. Variates with high sensitivity to enrichment and low background variability were considered reliable indicators, while variates that failed to change following enrichment or changed without enrichment were considered unreliable indicators. Contrary to expectations from other perturbations, community and ecosystem variates were more reliable indicators of enrichment than species and genera. Productivity, biomass, diversity, and evenness changed significantly only during the first year of enrichment and only in enriched lakes. In contrast, changes in species and genera were unreliable due to high background variability: most taxa were not present often enough during a single year to reliably assess whether they had increased or decreased compared to previous years. Although species change is a useful indicator of toxic chemical stress, this conclusion does not appear to extend to nutrient enrichment.

Pigment Dynamics in a Coastal Bottom Boundary Layer and Its Relation to the Physical Regime: Measurements Using an In Situ Fiber Optic Fluorometer

D'Sa, Eurico J. 1996
University of Southern Mississippi (USA), 185 pp.

An understanding of the processes which control the near-bottom distribution and transport of particulate organic matter produced by phytoplankton is essential in determining its fate and the linkages of carbon budgets between the various shelf regions. A variety of evidence suggests such linkages may be important in the Cape Hatteras shelf and slope regions. Time series observations of chlorophyll (chl) fluorescence in the bottom boundary layer are examined in relation to physical processes over the inner continental shelf at a 20 meter site near Cape Hatteras, North Carolina for a 29 day period from 24 July to 22 August 1994.

An autonomous multisensor in situ fiber-optic fluorometer was developed and deployed in the bottom boundary layer in conjunction with a BASS (benthic acoustic stress sensor) tripod for estimating the vertical photosynthetic pigment structure on sampling scales that were directly compatible with physical observations. Performance evaluation of the instrument showed stable operation during long-term field operations. Simulation analysis of particle size and a theoretical model of the phytoplankton package effect on fluorescence measurements by the dual fiber-optic sensor of the fluorometer indicated variability of fluorescence yield which were minimized by multiple sampling.

Time series estimates of near-bottom pigment concentrations near Cape Hatteras were variable with high maxima (exceeding 100 milligrams per cubic meter). Periods of increased sediment suspensions and transient episodes of high pigment concentrations during the first half of the deployment period were associated with increased wind and wave activity in the region. High pigment concentration in surficial sediments were measured at deployment time and may have been available for resuspension during this period. A storm front on 7 August 1994, subsequent stratification and occurrence of low salinity events at the experiment site determined the pigment field in the near bottom waters for the remainder of the deployment period. Pigment fluxes were dominated by episodic transport events and relatively high magnitudes of net carbon transport onshore (3.9 grams chl per square meter per day) and to the south (4.5 g chl per square meter per day). Fluorescence measurements with the multisensor fiber-optic fluorometer provided small-scale description of the pigment field in relation to the physical processes and an accurate assessment of near-bottom pigment transport.

The Influence of Zooplankton on Biogeochemical Fluxes and Stoichiometry in an Arctic Marine System

Daly, Kendra L. 1995
University of Tennessee (USA), 183 pp.

The role of the dominant zooplankton, calanoid copepods, in Arctic marine carbon and nitrogen cycles was investigated in the Northeast Water Polynya off the coast of Greenland during the summer of 1992 and 1993. This high-latitude system was characterized by relatively high molar carbon:nitrogen (C:N) ratios for dissolved and particulate pools in the euphotic zone relative to Redfield stoichiometry. Elevated C:N ratios (8.9) of particulate organic matter were interpreted to be a response by phytoplankton to nutrient limitation in open water regions, particularly in larger cells, and C:N ratios (9.6) of female copepods were even higher due to lipid storage. Moreover, C:N ratios (33.2) for copepod fecal pellets were higher than reported for other systems, presumably from the combined effect of copepods ingesting food with a relatively low nitrogen content and assimilating nitrogen more efficiently than carbon. Average daily egestion in female CALANUS HYPERBOREUS was equivalent to 8% of body carbon and 2% of body nitrogen, whereas carbon dioxide respiration and ammonium excretion were approximately in balance (1% of body carbon and nitrogen). Regression analyses indicate that a large proportion (50 - 80%) of the variability in these rates was explained by carbon and nitrogen concentrations in food. In addition, estimates of community rates suggest that copepods, on average, consumed a considerable amount of the primary production (45%) and egested fecal matter equivalent to 20% of the carbon and 12% of the nitrogen particulate flux sinking from the upper 50 meters of the water column, but excreted less than 10% of the ammonium utilized by phytoplankton in the surface layer. Furthermore, mass-balance calculations indicate that female copepods recycled ingested carbon to biomass, egested fecal matter, and excreted dissolved organic carbon in approximately equal proportions, while ingested nitrogen primarily was excreted as dissolved organic nitrogen. Hence, copepods formed carbon-rich particulate matter, but resupplied dissolved pools at relatively low C:N ratios. Because C:N ratios of particulate and dissolved pools and their associated fluxes were higher than Redfield proportions, it was concluded that the use of the Redfield ratio underestimated carbon export by 25% and therefore may be unsuitable for Arctic systems.

Role of Compensatory Mechanisms in the Population Dynamics of Lake Trout (*Salvelinus namaycush*) in the U.S. Waters of Lake Superior

Ferreri, Cecilia P. 1995
Michigan State University (USA), 86 pp.

Lake trout (SALVELINUS NAMAYCUSH) populations in Lake Superior have exhibited differing levels of abundance through time and thereby provide an opportunity in which to study the effects of compensation on population regulation. I explored the role of compensatory mechanisms in the population dynamics of lake trout in the Michigan and Wisconsin waters of Lake Superior during three time periods: the pre-sea lamprey period, prior to 1950 when lake trout were at a relatively high abundance and the fishery was the primary source of lake trout mortality; the sea lamprey dominant period, during the 1950's and 1960's when lake trout were at a very low abundance due to sea lamprey predation and over-exploitation; and currently, from 1985 to 1993 when wild lake trout abundance was at a moderate level.

The role of compensatory mechanisms was evaluated using a life table approach. Age-specific fecundity and survival schedules were incorporated into a Leslie projection matrix to calculate the finite rate of population increase (lambda). Individual growth, fecundity, and age-0 survival rates were calculated for each lake trout population and compared between time periods. Elasticity analyses were performed to determine the proportional contribution of each matrix parameter to the population growth rate during the three periods.

I found that individual growth rates, age-specific fecundity, and age-0 survival rates changed in response to the different levels of lake trout abundance during each of the study periods in both sites. Lake trout during the sea lamprey dominant period, which experienced the lowest abundance and highest mortality levels, exhibited the fastest individual growth rates, the highest age-specific fecundity, and the highest age-0 survival. These high rates contributed to the relatively high production potential exhibited by lake trout during the sea lamprey dominant period as compared to lake trout during the pre-sea lamprey or the current periods. Survival, particularly during the pre-reproductive ages, made a greater contribution than fecundity to the population growth rate of lake trout during the current time period. Reducing fishing mortality, which has its greatest impact on lake trout that are about to become mature, has a greater effect on the population growth rate than reducing sea lamprey induced mortality by an equal percentage.

Structure and Functioning of Macroinvertebrates in a Stream Continuum of the River Stradomka

Fleituch, Tadeusz M. 1996
University of Lodz (Poland), 220 pp.

The main purpose of the study, based on the river continuum concept (Vannote et al.,1980), was to examine longitudinal structure, diversity, and functional organisation (functional feeding groups-FFG) of benthic communities in relation to system productivity, dynamics of particulate organic matter, and hydrological gradients of the whole catchment along with habitat heterogenity. Patterns in invertebrate community were determined in the submountain river Stradomka (Poland). Such studies are very rare, especially in Europe. Net daily production of benthic communities was negative and the heterotrophic processes prevailed. Gross production was positively related to PAR and PO4 concentration. The 3 groups DIPTERA, TRICHOPTERA, and EPHEMEROPTERA were the taxonomically most abundant. The highest taxon richness was found in the second stream order-67 taxa. In all seasons, habitats, and stream orders, the highest densities were indicated by dipteran and mayflies. Only 12% of the total 118 determined taxa in the catchment were present in all stream orders. Again, 29 taxa were restricted to headwater streams and 36 others to downstream sections. Longitudinal succession of species replacement was found for the 3 genera. Faunal density ranged widely, especially in the 3-4 orders (over 60 thousand individuals per square meter) however it usually was about 10 thousand individuals per square meter. Seasonally, the lowest benthic fauna density occurred in summer, and the highest in autumn and spring. Annual distribution of benthic fauna density in relation to stream order showed an exponential relationship. The highest biomass was observed in the fourth stream order. Average density and biomass were higher in winter than in summer. Densities of bottom fauna differed between habitats. Their highest values were found in riffles. At most river stations collectors dominated by density, however in the upstream sections shredders prevailed. Based on biomass a marked patterns of FFG distribution were estabilished for: collectors, feeding filters, and predators that dominated in the middle and downstream river parts; scrapers and shredders prevailed in headwater reaches; facultative group of collector/scrapers in the middle part. There is still little information on FFG biomass of benthic fauna in the context of their longitudinal distribution. Analysis of longitudinal distribution of FFG showed that shredders and scrapers were replaced by collectors, and again a set of 2 FFG (predators and shredders) were followed by filtrators along downstream direction. These shifts in functional fauna organisation have not been so far documented by other authors with the use of FFG biomass. However diversity of bottom community in lotic habitats was a little greater than in pools. Diversity did not correlate with the stream order. Longitudinal changes in functional organisation of benthos were better explained by faunal biomass. According to deterministic model of RCC and presented results, changes in stream morphology, abiotic parameters of the stream water and changes in riparian canopy development in Stradomka Catchment implied a specific functioning of benthic fauna communities. Observed changes along river gradient indicated a decrease of shredders that depended on coarse particulate organic matter, an increase of collectors and filter feeders which were based on fine detritus and suspended seston. The presented results confirmed most of tenets predicted by the RCC.

Growth Dependence of Coccolith Detachment, Carbon Fixation and Other Associated Processes by the Coccolithophore *Emiliania huxleyi*

Fritz, Jennifer J. 1997
University of Miami (USA), 178 pp.

This series of experiments was designed to examine a variety of carbon-related processes in the cosmopolitan coccolithophore species EMILIANIA HUXLEYI, including photosynthesis, calcification, coccolith biomass, size, integrity, production, and detachment rates. Separate experiments were conducted in different environmental growth conditions including increasing turbulence levels, light limitation and nitrate limitation.

With respect to turbulence, cell growth in exponential growth phase was reduced up to 38% at high kinetic energy dissipation rates, above 3.3 square centimeters per second cubed, while photosynthesis and calcification were enhanced at 3.3 square centimeters per second cubed. During stationary phase, organic and inorganic carbon fixation were severely reduced due to turbulence, whereas coccolith detachment increased significantly.

Light- and nitrate-limited continuous cultures focused examination to specific cellular growth rates. Photosynthesis and calcification increased with growth rate under nitrate limitation. In contrast, calcification and coccolith production did not co-vary with growth, as determined by changing coccolith carbon content. For nitrate-limited cells, coccoliths contained more carbon at low growth rates than at higher growth rates. Different types of growth limitation revealed a trend of increasing coccolith carbon contents from nitrate to light to carbon limitation.

With respect to coccolith detachment, intrinsic rates of increase of detached coccoliths (per day) equaled cellular growth rates (per day) for both light- and nitrate-limited cells, and thus, could be used as a species-specific estimator of growth rate. Both coccolith detachment rates and intrinsic rates of increase of detached coccoliths were determined in the Gulf of Maine and during the monsoon and intermonsoon periods in the Arabian Sea under non-blooming conditions to test this hypothesis. Average coccolith detachment rates for those regions were 5, 5.5, and 4.2 coccoliths per cell per day, respectively. Intrinsic rates of increase of detached coccoliths predicted regional growth rates of 0.2, 0.42, and 0.3 per day, respectively, all of which are reasonable estimates of growth rate in this coccolithophore.

Control of Rotifers in a Meso-Eutrophic Lake by Bottom-Up and Top-Down Processes: Field Studies and Enclosure Experiments

Fussmann, Gregor. 1996
Christian Albrechts University (Germany), 124 pp.

In two consecutive years rotifer and crustacean plankton displayed alternating dynamics in the meso-eutrophic Schoehsee (Ploen, Germany). During the clear-water phase daphnids increased and excluded rotifers from the plankton. Only after the DAPHNIA population had crashed rotifers attained higher densities. In summer, when phytoplankton biomass was highest, rotifers reached their peak densities. Copepods could be abundant during this time, daphnids, however, remained unimportant throughout the summer.

Based on these observations I performed a series of enclosure experiments in the lake. The objective was to assess the importance of bottom-up and top-down processes for the rotifer plankton. Depending on the experiment phytoplankton resources and/or crustacean plankton were manipulated.

Quantitative as well as qualitative alterations of phytoplankton resources had a strong impact on the birth rates of almost all rotifer species. When condensed natural lake seston was added to the enclosures birth rates increased dramatically for some rotifer species suggesting resource limitation of these species in the lake.

In enclosures containing crustacean plankton rotifers reached lower densities than in enclosures without crustaceans. In most cases rotifer birth rates decreased in the presence of crustaceans. Mortality increased only in a few instances. Thus, in this study crustaceans were most likely to influence rotifers as exploitative competitors (bottom-up). Top-down processes like predation were found to be less important. The susceptibility to bottom-up and top-down mechanisms, however, varied very much with the type of rotifer species present.

Daphnids had the highest potential to control rotifers among the crustacean taxa present in the Schoehsee. Exploitative competition for phytoplankton turned out to be much more important than mechanical interference which occurs when rotifers are killed by the movement of a cladoceran's filtration apparatus. Cyclopoid copepods were found to be predators of rotifers whereas the predacious cladoceran Leptodora had no effect on the rotifers.

In conclusion, it was possible to show in a series of in situ experiments that biotic factors like competition and predation are able to influence natural populations in terms of abundance, diversity or reproductive success.

Nitrate Assimilation in the Marine Diatom *Skeletonema costatum*: Biochemical Characterization and Environmental Regulation

Gao, Yu. 1997
University of Southern California (USA), 211 pp.

The dissertation research investigated the cellular and molecular mechanisms that regulate nitrate assimilation, the major pathway by which marine phytoplankton acquires nitrogen (N) from the environment. Nitrate reductase (NR) catalyzes the reduction of nitrate to nitrite, a rate-limiting step in nitrate assimilation. As a key regulatory component in nitrate assimilation, NR from a marine diatom, SKELETONEMA COSTATUM, was targeted for investigation. The biochemical and regulatory features of the diatom NR were investigated and the applicability of NR abundance as an index for estimating new production was explored.

Biochemical characterization using both purified NR and cell-free extracts revealed several unique features of the enzyme quite distinct from vascular plant NRs. The features included the molecular mass of native enzyme, heavy metal sensitivities of the activity and temperature dependence of the enzyme activity and abundance. The polyclonal antibodies generated against purified diatom NR were demonstrated to be specific for diatoms. The antigenicity of NRs from marine phytoplankton are divergent. These features alone provided significant insights and entrees into the central role of NR in controlling the production dynamics of phytoplankton in the ocean.

Environmental impacts on the initial events in nitrate assimilation (nitrate transport and reduction) were investigated by monitoring NR activities, NR protein abundance and internal nitrate levels determined by a rapid method developed in this research. The results demonstrated the independent environmental controls on nitrate transport and reduction. Long-term exposure to ammonium completely eliminates nitrate assimilation capacity. However, induction of nitrate transport and reduction capacities by nitrate and light is rapid, requires both light and nitrate, and involves de novo synthesis of NR protein and a nitrate transport system. Further, it is concluded that internal nitrate and redox state associated with photosynthetic electron transport may provide a regulatory signal essential for the induction. It was also demonstrated that ammonium inhibition of nitrate assimilation is at the level of nitrate transport rather than nitrate reduction and that ammonium and nitrate assimilation can occur concomitantly providing that internal nitrate pools are adequate.

The use of antibodies to detect NR protein in intact phytoplankton cells and to trace NR abundance in response to envrionmental shifts were explored. It was demonstrated that NR protein is not constitutively expressed, its abundance is sensitive to environmental shifts, and it may be a better index than in vitro activity for estimating nitrate assimilation potential. Further, a protocol for in situ detection of NR was developed, which allows for detecting NR protein in individual cells by flow cytometry and resolving fine scale dynamics of NR protein abundance in response to environmental transitions.

This research has not only significantly advanced our understanding of the underlying biological mechanisms that control the production dynamics of marine phytoplankton, but has also opened a variety of research opportunities in NR biochemistry, phylogeny, eco-physiology and molecular biology. In addition, the present investigation demonstrated the significance of biochemical and molecular approaches and subcellular features of marine organisams for obtaining mechanistic understandings of biological processes in the ocean.

Regional and Temporal Variation in the Ecology of an Encrusting Bryozoan in the Gulf of Maine

Genovese, Salvatore J. 1996
Northeastern University (USA), 242 pp.

Suspension feeding organisms dominate subtidal habitats in the Gulf of Maine (GOM) at depths of 25-40 meters. PARASMITTINA JEFFREYSI is an encrusting cheilostome bryozoan found in this zone throughout the GOM. Space is generally a limiting resource in these communities, and initial observations suggested that P. JEFFREYSI was able to rapidly overgrow neighboring organisms. Regional variation in the GOM between coastal and offshore locations for both flow speed and particle concentration make it an ideal location to study the effect of these factors on the growth of P. JEFFREYSI. A secondary goal was to determine if differences in growth rates between sites would lead to differences in either the demography or competitive ability of this organism. Experiments were conducted over a 5 year period at 2 offshore and 2 coastal sites.

Particle flux measurements indicated that offshore flow speeds were over 3-fold greater than flow speeds at the coastal sites. Chlorophyll a concentrations, as well as particulate quantity and quality were generally greater at offshore sites, while sedimentation rates were greater in the coastal region. Both transplanted colonies and those within natural quadrats displayed no regional difference in growth, suggesting that the interactive effects of flow speed and particle concentration are acting upon feeding success and growth in opposing directions at each location, resulting in the net effect of no difference.

The amount of surface area, or percent cover, occupied by a sessile colonial organism depends on both density and individual colony sizes, while rates of recruitment and mortality provide a more complete understanding of the factors determining spatial cover. An examination of the spatial variation in each of these population parameters for P. JEFFREYSI indicated differences among sites for all parameters except percent cover. This suggests that: (1) percent cover alone may not be a sufficient indicator of differences in population dynamics among sites; (2) although there were no differences among sites in the spatial cover of P. JEFFREYSI, this relationship was maintained through different processes at each site. Demographic comparisons using log-linear analysis of size-classified transition matrices indicated that the subsequent fate of P. JEFFREYSI was conditional on original colony size and independent of both spatial and temporal effects. In relative terms, temporal variation was found to exert a greater effect than spatial variation on the demography of this bryozoan.

There was no overall difference in the competitive ability of P. JEFFREYSI at coastal and offshore sites. The gain or loss of spatial cover for P. JEFFREYSI was primarily due to disturbance effects at the offshore sites, while interactions with a hydroid complex (hydroids and detritus bound by amphipod tubes) were of greatest importance at the coastal sites. In the few time intervals where the strength of competitive interactions appeared to be significant, it was due to interactions with a single abundant species. Competitive interactions between P. JEFFREYSI and most species were indeterminate, with either species overgrowing the other in certain cases.

Studies on Freshwater Ostracods of Kerala

George, Sunny 1994
University of Calicut (India), 272 pp.

An extensive survey for freshwater ostracods in the state of Kerala revealed the presence of 32 valid species. This includes 5 species new to science, 7 first records for India and 14 first records for Kerala.

All the new records of ostracods from India were collected mainly from the paddy fields. Outside India they are known only from Indonesia, Malaysia, and the Philippines. Since the last thorough survey for freshwater ostracods in this region in 1959 (published by Hartmann 1964) was not able to record any of these species in spite of their abundance, it is legitimate to suspect that these species might have been introduced here after that period.

Resting eggs of ostracods were found attached onto the dry rice seeds. These eggs were hatched when introduced into filtered water. This indicates that rice seed transport can be a passive dispersal agent for ostracods. During 1960's huge quantities of rice seeds were brought to Kerala from the Indo-Malayan sub-region, without any quarantine measures, as a part of the "Green Revolution." This mainly includes the several rapid growing varieties of rice developed in the International Rice Research Institute in the Philippines. The present study gives ample proof that there was a biological invasion of Indo-Malayan ostracods into the paddy fields of Kerala which is an unknown impact of the "Green Revolution."

The introduced species are thriving very well in Kerala since the ecological conditions of paddy fields are almost similar to that of Indo-Malayan area. Among paddy fields many ostracods are considered pests due to their voracious consumption of blue-green algae.

Ecological Genetics and Mate Recognition Systems in Sympatric Rotifer Populations

Gomez, Africa. 1996
University of Valencia (Spain), 226 pp.

This dissertation is a study of the population structure and dynamics, and the differentiation of specific mate recognition systems, including their ecological context, in populations of the common brackish water rotifer BRACHIONUS PLICATILIS in the Prat de Cabanes-Torreblanca, a wetland having a high habitat diversity. Using Allozyme Electrophoresis, we analyzed the population structure of this taxon during more than an annual cycle. We also performed mating tests between strains, including genetically distinct strains collected in the marsh, and allopatric strains collected world-wide, and studied the ecological factors that explain the seasonal succession found in the marsh, and the patterns of sexual reproduction in natural populations.

Our results help to better understand the ecological diversity and evolutionary dynamics of monogonont rotifer populations, as they show that B. PLICATILIS, usually considered a cosmopolitan and ecological generalist species, is, on the contrary, a complex of three species ecologically specialized with regard to temperature and salinity, and with remarkable differentiation in sexual reproductive patterns and the signals used in mating, factors that, together differentiate the specific mate recognitions systems of these species. Furthermore, our results with allopatric strains show that, either there is a higher number of sibling species in this taxon, or that there is a strong geographic divergence in the signals used in mating behavior among conspecific populations. In our work, we propose models of speciation, both sympatric and allopatric, that are suitable for organisms reproducing through cyclical parthenogenesis, as well as procedures to analyze the alpha-taxonomy of these organisms.

Phytoplankton-Zooplankton Interactions in Natural and Experimental Conditions in a Tropical Reservoir (El Andino Reservoir, Venezuela)

Gonzalez, Ernesto J. 1996
Central University of Venezuela (Venezuela), 347 pp.

To study the effects of nutrient enrichment (N and P) and zooplankton grazing over the phytoplankton community structure in El Andino Reservoir (Venezuela), in situ mesocosms were isolated for 6-7 days. Mesocosms consisted in polyethylene bags (42 centimeters diameter and 71 cm length) filledwith 10 liters of filtered epilimnetic reservoir water. Experiments were carried with a frequency of one experiment per month (January to December, 1993). The experimental design was as follows: (1) no nutrients, no zooplankton; (2) with nutrients (150 NH4Cl micromol/ml and 10 KH2PO4 micromol/ml, 1ml per liter of sample), no zooplankton; (3) no nutrients, with zooplankton present in the water column (hauled from 6 to 0 meters with a zooplankton net, mesh size 80 microm); (4) with nutrients as in (2), with zooplankton as in (3).

The nutrient enrichment caused an increase in phytoplankton biomass (measured as chlorophyll-A) in the mesocosms, also the increase of all algal groups abundance, except Cryptophyta and Pyrrophyta. In spite of this, relative proportions of Cyanobacteria decreased in most cases, while Chlorophyta and Bacillariophyta increased, probably due to their greater competitive ability for phosphorus. After enrichment, SCENEDESMUS was the dominant species from January to June, while from July to December DACTYLOCOCCOPSIS and LYNGBYA dominated in the enriched mesocosms.

Herbivorous zooplankton mainly grazed on diatoms, although particulate matter was present in almost all the gut contents analysed (cleared with Hoyer's medium). Particulate matter probably consisted of micro-algae, detritus, triturated algae, and inorganic material. Zooplankton excretion caused a slight increase in phytoplankton biomass and P concentrations.

The results suggest that, at the initial stages of a eutrophication process, phytoplankton would increase its abundance and biomass, but would not change its community structure. Since there was a strong correlation between total phosphorus and chlorophyll-A (bottom-up control), it is suggested that eutrophication could be avoided by controlling P input to the reservoir.

Allelopathic Actions by Submersed Macrophytes on Epiphytes and Phytoplankton: Algicidal Hydrolyzable Polyphenols from *Myriophyllum spicatum*

Gross, Elisabeth M. 1995
Christian-Albrechts-University, Kiel (Germany), 148 pp.

Submersed macrophytes have to compete with epiphytes and phytoplankton for light and nutrient resources. Frequent observations show alternating stable states of either submersed macrophyte or phytoplankton dominance in shallow eutrophic lakes (Scheffer et al. 1993). The production and excretion of allelochemicals may enable submersed macrophytes to dominate over phytoplankton despite abundant nutrient availability in the open water.

The allelopathic potential to suppress phytoplankton of 19 macrophytes was determined. Special emphasis was placed on MYRIOPHYLLUM spp. and related species. Nine of the tested species exhibited a strong algicidal and cyanobactericidal activity (CERATOPHYLLUM DEMERSUM, C. SUBMERSUM, FONTINALIS ANTIPYRETICA, HOTTONIA PALUSTRIS, MYRIOPHYLLUM spp., and PROSERPINACA PALUSTRIS). MYRIOPHYLLUM and PROSERPINACA belong to the Haloragaceae. Members of this family showed the highest inhibitory activity which is based on hydrolyzable polyphenols as active compounds. All tested Haloragaceae contain very high concentrations of phenolic compounds (6 - 15 % of dry weight). These concentrations are about one order of magnitude higher than that measured in other submersed macrophytes.

The main allelochemical from M. SPICATUM (milfoil) was isolated and structurally identified. This hydrolyzable polyphenol, Tellimagrandin II, is present at concentrations of about 1 - 1.5% of the dry weight. Different, yet unidentified, hydrolyzable polyphenols account for the algicidal activity of other tested Haloragaceae. An axenic culture of milfoil was established. Axenic and field-sampled milfoil did not exhibit different patterns of polyphenols and Tellimagrandin II, suggesting that these defensive compounds are not induced by epiphytes. This allowed the controlled study of released compounds into the surrounding medium with axenic plant material. Milfoil exudes several polyphenolic compounds, among them traces of Tellimagrandin II, ellagic acid and three as yet unidentified hydrolyzable polyphenols. Signals for these exuded compounds were also found in the culture filtrate of non-axenic plants, but due to fast bacterial degradation these signals faded out with increasing incubation time. Both plant-extracted, among them Tellimagrandin II, and exuded polyphenols exhibited a strong inhibition of algal extracellular alkaline phosphatase activity (APA) of various algae and cyanobacteria as well as a natural sample of epiphytes.

Thus, M. SPICATUM as well as other Haloragaceae and submersed macrophytes may interfere with vital functions of epiphytes and phytoplankton. These interactions may help maintain dominance of submersed macrophytes, such as M. SPICATUM, in shallow eutrophic lakes.

Occurrence, Formation, and Microbial Processes of Lake Snow Aggregates and Their Significance in Organic Matter Cycling in Lake Constance

Grossart, Hans-Peter F. 1995
University of Constance (Germany), 223 pp.

The abundance, composition, and bacterial colonization of macroscopic organic aggregates (lake snow) were studied from March until November 1993 in Lake Constance, Germany. In addition, the concentration of particulate carbon (POC) and the amount, composition, and bacterial colonization of particulate matter (PM) collected in a sediment trap at 50 meter depth were investigated. Further, concentrations of transparent exopolymer particles (TEP), chlorophyll, POC, and the species composition of phyto- and zoo-plankton in the ambient water were determined. To study formation, microbial colonization, and bacterial decomposition of lake snow aggregates under defined conditions laboratory experiments were performed by incubating water samples in rolling tanks.

The abundance and composition of aggregates showed a pronounced seasonal and vertical pattern in close relation to POC, phyto- and zooplankton dynamics, and wind conditions. Seasonal and vertical dynamics of lake snow aggregates and of sinking PM reflected the occurrence of phytoplankton blooms in spring, summer, and fall and sedimentation losses of zooplankton during the clear water phase. Aggregates were mostly of phyto- and/or zooplankton origin and were characterized by high amounts of POC and particulate-combined amino acids (PCAA).

Numbers of aggregates ranged between <1 and 50 per liter. Formation of lake snow aggregates occurred mainly through 2 mechanisms: de novo production, and biological-enhanced physical aggregation of small particles. In spring, the peak of TEP concentrations appeared simultaneously with that of lake snow aggregates whereas peaks in summer and fall followed those of aggregate abundances. More detailed analysis indicated that the role of TEP in aggregate formation varies throughout the season.

POC on aggregates comprised between 0.15 and 28% of total POC and constituted only a minor fraction of total POC during phytoplankton blooms but calculated loss rates of POC through lake snow aggregates were much higher. Due to their high percentage of organic matter aggregates were densely colonized by a rich and diverse microbial community which showed a characteristic succession in time. Respiratory and extracellular enzyme activities many times higher on lake snow aggregates than in the surrounding water resulted in a rapid and efficient decomposition of POM also in the aphotic zone. This leads to supplying planktonic bacteria in these depth with dissolved organic matter (DOM) and may be one major pathway of substrate supply for them when the lake is thermally stratified. However, when sinking POM was deprived of labile organic substrates attached bacteria scavenged dissolved substrates, e.g. amino acids, from the surrounding water and may act as a sink. This finding complicates the one-way concepts of bacterial mediated interactions between POM and DOM in aquatic environments.

Ecological Studies on the Crayfish *Pacifastacus leniusculus* (Dana)

Guan, RuiZhang. 1995
University of Buckingham (United Kingdom), 185 pp.

This study was undertaken to examine some of the interactions between the introduced crayfish PACIFASTACUS LENIUSCULUS and its environment, and so to evaluate its adaptation and impact on the river system. Two methods for marking or tagging crayfish had been developed. one was an improved marking method. The other was the application of Passive Integrated Transponder tag systems.

In the river Great Ouse, P. LENIUSCULUS grew faster than the native crayfish AUSTROPOTAMOBIUS PALLIPES. In 1994, the mean number of pleopodal eggs per female at the end of April was 158. A recruitment of 70 juveniles per square meter was estimated for the original pool (P2) of introduction. By May 1994, 10 years after its first introduction, P. LENIUSCULUS had dispersed 5.5 kilometers (km) up river and 5.9 km down river from the point of introduction.

In 1993, the density and biomass (wet weight) of P. LENIUSCULUS were highest in summer at 4.0 per square meter and 133 grams (g) per square meter respectively, with annual means of 2.2 per square meter and 82 g per square meter for crayfish >30 millimeters (mm) CL in P2. The equivalent figures were 15 per square meter and 78 g per square meter, with annual means of 6.1 per square meter and 33 g per square meter for all sizes of crayfish in an adjacent riffle downstream. The estimated annual production of crayfish >35 mm CL in P2 was 52.58 g per square meter wet weight, 8.55 g per square meter dry weight, or 29.45 kilocalories per square meter, with an annual mean standing crop of 118 g per square meter wet weight and a turnover ratio of 0.44.

The juveniles of P. LENIUSCULUS ingested more benthic invertebrates, while adults fed more on vascular detritus and fish. Cannibalism occurred in all sizes of crayfish. Twenty-two food groups were classified from the gut contents over four seasons. The main diets were vascular detritus, filaments of green alga Cladophora, crayfish fragments, Chironomidae and Ephemeroptera. The estimated daily ration ranged from 0.22-6.02% of body wet weight. The gross efficiency of food conversion decreased with increase in crayfish size.

P. LENIUSCULUS had significant effects on the two main benthic fishes, COTTUS GOBIO L. and NOEMACHEILUS BARBATULUS (L.). In four riffles occupied by the crayfish, benthic fish were least abundant in the riffle where crayfish were most abundant, and increased gradually both up and down the river, as crayfish abundance decreased. In the laboratory experiments, crayfish predated the benthic fish and expelled the fish from shelters which the crayfish then occupied themselves. These interactions, together with the evidences of overlapping diets and the fish remains frequently found in the guts of crayfish from the river, suggested that it was the crayfish that were responsible for the reduction in the abundance of benthic fish in the riffles.

P. LENIUSCULUS was proved to be a burrowing species. It excavates extensive burrows in the mud banks and in the bottom of the river, with the highest mean density of 25.7 per meter of bank. High burrow densities resulted in the collapse of the river banks and can cause considerable soil erosion and river sedimentation.

Tritium in Ukrainian Freshwater and Its Effects on Hydrobionts

Gudkov, Dmitri I. 1996
Ukranian National Academy of Sciences (Ukraine), 224 pp.

The research, which we have carried out, is timely, because tritium is the major radioactive component of discharges from nuclear power plants (NPPs), equipped with BWR and PWR reactors and their analogies - WWER-440 and WWER-1000 (80% of Ukrainian NPPs are equipped with these reactors).

In accordance with the major objectives of the Ph.D. dissertation, the following works were completed:
1) for the period from 1992 to 1995 we have studied tritium distribution in natural and artificial water bodies at the territory of Ukraine (these studies were focused mainly at the water bodies under NPPs impact, including the Dnieper river, its tributaries and water reservoirs);
2) we have analysed the causes of increased tritium contents in the Dnieper cascade water reservoirs in 1994;
3) using mathematical modelling methods, we have evaluated impacts of NPPs (equipped with WWER reactors) on tritium contents in nearby water bodies;
4) we have evaluated tritium inflow into the Black Sea with the Dnieper water in 1992 - 1995;
5) we have studied tritium distribution in waste bodies of the Chernobyl NPP "exclusion zone" within the period from 1993 to 1995;
6) we have reviewed possible consequences of the Chernobyl disaster as for tritium contents in water bodies;
7) we have experimentally studied changes in somatic and cytogenetic parameters of CYPRINUS CARPIO L., PLANOBRIS VORTEX L. and DAPHNIA MAGNA Str. under chronic impact of tritium;
8) we have studied tritium effects in several generations of hydrobionts;
9) we have studied stimulating effect of low-dose tritium activity on development of eggs and larvae of CYPRINUS CARPIO L.;
10) we have studied combined impact of tritium and lead on viability of D. MAGNA Str;
11) we have analysed probable mechanisms of protective and recovery capacity of hydrobionts, allowing them to recover from radiation-induced damage.

The most important results of the studies incorporate: (1) the impact assessment of Ukrainian NPPs, equipped with WWER reactors, as regional sources of tritium inflow into the water bodies, located nearby the NPPs sites; (2) the identification of toxic effects, that were caused by tritium impact on hydrobionts, at tritium levels registered in cooling ponds of Ukrainian NPPs.

Cycling of Dissolved and Colloidal Organic Matter in Oceanic Environments as Revealed by Carbon and Thorium Isotopes

Guo, Laodong. 1995
Texas A&M University (USA), 230 pp.

The cross-flow ultrafiltration and multiple isotopic tracers (13C, 14C, 230Th, and 234Th) were used to study the dynamics of dissolved organic matter (DOM) in the Gulf of Mexico and the Middle Atlantic Bight. A considerable fraction of the traditionally defined DOM was actually in a colloidal form. Colloidal organic carbon (COC1, 1 kiloDalton (kDa)-0.2 micrometer) comprised ~60% of the bulk dissolved organic carbon (DOC) in estuarine waters, decreasing to ~30-40% in oceanic waters. High molecular weight (HMW) COC10 (10 kDa-0.2 microm) made up 3-15% of the DOC pool, with highest abundances in estuarine waters and lowest ones in deep oceanic waters. A conservative mixing behavior of DOC was found in slope waters with no difference between study areas and seasons, indicating that water mixing processes are important factors in controlling the distribution of DOC in the ocean and thus the overall residence times of oceanic DOC are on the similar time scales as water mixing. Delta (del) 14C values of both colloidal organic matter 1 (COM1) and COM10 in surface water were generally high, reflecting their contemporary inputs and shorter turnover times. Values of del 14C for bottom water COM10, in contrast, could be much lower depending on its source functions. Thus, apparent 14C ages of the bulk DOM are the weight-averaged ages of different DOM fractions with varying molecular weights and reactivities. A three-component del 14C model was used to further elucidate the heterogeneity of bulk DOM. Organic carbon/nitrogen (C/N) ratios of HMW DOM, which are significantly higher than those of bulk DOM pool, increased with decreasing sizes and decreased from nearshore to offshore. Three colloidal end-members were identified with distinct isotopic and chemical composition: estuarine colloids with high del 14C values, high C/N ratios, and lower del 13C values, offshore surface water (pelagic) colloids with intermediate del 14C values, lower C/N ratios, and higher del 13C values, and offshore deep water colloids with low del 14C values, intermediate C/N ratios, and variable del 13C values.

Turnover times of COM10 and COM1 derived from 234Th signatures were consistently short (1-60 days) regardless of apparent 14C ages, indicating that HMW colloids are turning over much faster than the bulk DOM pool. The partitioning of 234Th was broadly similar to that of organic carbon among dissolved, colloidal, and particulate phases, suggesting that Th isotopes can be used as a tracer to study the cycling of DOM in the ocean. The similarities in values of Th partitioning coefficients between dissolved, colloidal and particulate phases imply that the complexation between Th and organic matter is not solely controlled by the specific surface area or pool size of particle or colloid. Instead, the freshness and chemical composition of particulate organic matter (POM) and COM may strongly affect the scavenging of Th isotopes in seawater.

The Ecological Significance of Ground Water-Lake Interactions: Epibenthic Algal Communities

Hagerthey, Scot E. 1996
Michigan Technological University (USA), 160 pp.

The ecological significance of ground water-lake interactions was determined by comparing epibenthic algal biomass, species composition, diversity, ground water flux, pore water, and overlying lake water chemistry among five equal depth sites in Sparkling Lake, Wisconsin.

Epibenthic algal biomass and ground water seepage flux were positively correlated ($r=0.466$; $p<0.001$) indicating that the flow of water across the sediment-water interface enhanced epibenthic algal growth. Epibenthic algal biomass was significantly greater at sites characterized by high ground water discharge (chlorophyll-A range 4.0 to 65.0 milligrams per square meter; ground water flux range 5.0 to 74.0 milliliters per square meter per minute) than at sites characterized by low ground water discharge (chl-A range 2.0 to 21.0 mg per square meter; ground water flux range 1.5 to 3.5 ml per square meter per minute) or low ground water recharge (range -0.5 to -1.5 ml per square meter per minute). Pore water nutrients differed among sites. Pore water PO4 was significantly greater at high ground water discharge sites (range 29.2 to 110.7 micrograms phosphorus per liter) than at other sites (range <10.0 to 27.7 micro g P per liter), respectively. Pore water NH3-N, was significantly lower at high ground water discharge sites (range <10.0 to 566.0 micro g N per liter) than at low ground water discharge and recharge sites (range 61.4 to 1464.9 micro g N per liter).

Species diversity and richness of epibenthic algal communities in seepage lakes are also influenced by ground water-lake interactions. The species composition among sites were distinct. Regions of high ground water discharge were dominated by several species of diatoms indicative of high phosphorus concentrations, whereas communities at low ground water discharge and recharge sites consisted mainly of diatoms and cyanobacteria indicative of high nitrogen. Species diversity (H') and richness in regions of high ground water discharge were significantly lower than in regions of low ground water discharge and recharge.

These results suggest that the spatial heterogeneity and chemical characteristics of ground water flow may significantly influence epibenthic algal biomass. Furthermore, observed differences in species composition among sites also suggests important repercussions on epibenthic algal diversity within lakes. Results support the "paradox of enrichment," which predicts lower diversity as a consequence of increased limiting nutrients. Moreover, whereas increased ground water flux lowers diversity at a single site, the distinctiveness of the community contributes to the overall lake species diversity.

Phytoplankton, Zooplankton and Their Relationships in Two Lakes of Northern Italy

Hamza, Waleed M. Reyad. 1994
United Universities of Parma, Ferrara, Bologna and Roma (Italy), 172 pp.

The study concerned with the grazing of zooplankton communities on phytoplankton ones, and the effects of both abiotic and biotic factors controlling that direct interactions in Lakes Candia and Orta in northern Italy; very different in morphometry and trophic state. In-situ experiments were carried out at different seasons in the course of two years in both lakes, using a technique based on incubation and individual counting. That technique assures nearly natural conditions and more realistic data compared with those can obtained by other techniques (e.g. radioisotope method). On the other hand, a complex set of laboratory experiments dealing with the specific grazing problems and those emerged from the in-situ study were carried out. The experimental design considered different light and temperature conditions within sets of single zooplankton or species assemblages fed on single cultured algal species or on mixed natural populations sampled from both lakes.

Throughout the study period, specific methodologies and investigations were developed such as: (1) the establishment of the optimal zooplankton concentrations in the incubating chambers; (2) the approach of investigating the diurnal vertical migration (DVM) in Lake Candia; and (3) the original development of a rotary device for laboratory incubation under controlled light and temperature.

The obtained results have added some important progress in knowledge regarding: the grazing pressure, whose values, as realistic percent of removal of the standing algal biomass or of the daily primary production, are very rarely found in the literature; the specific algal selectivity by the feeding animals; the numerical relation between in-situ and laboratory grazing experiments using the developed simple technique; the demonstration of the importance of animal body length or of water temperature on community grazing activities; the demonstration of periodic water currents from the shore to the middle of the lake and back, operating a passive horizontal transport of the organisms (DHM). On the basis of observations in light and dark conditions, the hypothesis is made of the role of zooplankton vision in food selectivity. The hypothesis seems to be new, as present research on this matter is mainly directed at evaluating supposed chemoreception or mechanoreception phenomena.

The Influence of Dissolved Humic Material (Humic, Fulvic, and Hydrophilic Acids) on the Ecology of Marine Phytoplankton

Heil, Cynthia A. 1996
University of Rhode Island (USA), 483 pp.

Blooms of nuisance phytoplankton species often occur after periods of extensive rainfall and river runoff which introduce large quantities of dissolved humic material into coastal waters. The influence of hydrophobic (humic and fulvic acids) and hydrophilic acids extracted from river runoff on eight nuisance marine phytoplankton species was investigated. Additions of both organic fractions at concentrations from 5 to 50 micrograms per liter induced both quantitative and qualitative responses in all species examined. Organic additions stimulated cell yield and growth rate in the dinoflagellates GYMNODINIUM SANGUINEUM, PROROCENTRUM MICANS AND PRORCENTRUM MINIMUM, the raphidophyte HETEROSIGMA AKASHIWO and the diatoms ASTERIONELLOPSIS GLACIALIS and SKELETONEMA COSTATUM. Cell yield of GYRODINIUM AUREOLUM, however, decreased with additions of both organic fractions, although growth rate was not affected. The similarity in observed responses to both organic fractions in each species suggests that hydrophobic and hydrophilc acids influence phytoplankton growth via similar mechanisms and that the presence of these organic fractions at concentrations typically present in runoff can potentially stimulate bloom formation. Species specific responses to the addition of humic material included: an increase in chain length of the diatom A. GLACIALIS, increases in photosynthetic and respiration rates of the dinoflagellate P. MINIMUM as well as a direct corelation between growth rates of P. MINIMUM and specific molecular weight fractions of organic additions.

Qualitative effects observed with additions of humic material included the induction of meiosis (ALEXANDRIUM TAMARENSE, G. AUREOLUM, P. MICANS and P. MINIMUM), alternate vegetative cells forms (G. AUREOLUM, G. SANGUINEUM and P. MINIMUM) and aberrant cell forms (A. GLACIALIS AND S. COSTATUM). As well as a growth stimulator, dissolved humic material is hypothisized to serve as a chemical "cue" of nearshore environments suitable for the survival of the benthic cyst stage resulting from dinoflagellate meiosis, thus favoring long-term survival of bloom species. The complexities of both quantitative and qualitative responses exhibited by a wide variety of bloom species demonstrate that both hydrophobic and hydrophilic acids serve complex physiological and ecological functions in relation to the formation and development of nuisance phytoplankton blooms.

The Nutrition of Juvenile Deposit-Feeding Polychaetes: Ontogenetic Diet Changes and Food-Related Recruitment Bottlenecks

Hentschel, Brian T. 1995
University of Washington (USA), 155 pp.

Because deposit feeders dominate most sediments and their activities have profound effects on benthic communities, identifying the food resources that they assimilate and predicting their population dynamics are key issues in aquatic ecology. Though the diet of deposit feeders remains largely unknown, recent evidence suggests that juveniles of deposit-feeding species require more labile foods than those utilized by adults. My studies of ontogenetic niche shifts and their implications for population dynamics focused on tentaculate, deposit-feeding polychaetes and had four components.

First, a model of particle contact predicted that thinner feeding palps are biased toward contacting larger particles than thicker palps. Because palp and body size covary, the model predicts that juveniles will contact larger particles than adults. An experiment with glass beads and palp mimics of varying diameters (monofilament line) concurred. A feeding experiment with PSEUDOPOLYDORA KEMPI (Spionidae) also showed the trend. Assuming that particle size and food value correlate negatively, smaller juveniles will be biased toward relatively less-nutritious particles. This foraging constraint associated with palp size and a digestive constraint associated with gut size suggest that juveniles must forage differently than conspecific adults.

Delta (del) C-13 was used to trace ontogenetic changes in diet as juveniles grow. P. KEMPI collected from Skagit Bay and False Bay, Washington showed significant variation in del C-13 with body size, while individuals fed a known diet did not. HOBSONIA FLORIDA (Ampharetidae) from Skagit Bay and POLYDORA LIGNI (Spionidae) from False Bay showed similar trends. Comparisons of the worms' del C-13 to that of potential foods suggested that detritus from macroalgae dominates adult diets, while benthic diatoms dominate juvenile diets.

The importance of benthic diatoms was tested by reducing their growth in situ. A method to perfuse porewaters with the herbicide DCMU was developed. Achieved DCMU concentrations were below levels known to be toxic to animals and significantly reduced the abundances of diatoms, juvenile H. FLORIDA, and a meiofaunal oligochaete that competes with juvenile H. FLORIDA.

To explore the recruitment implications of the ontogenetic changes in diet, I quantified the energy reserves of individuals of varying sizes using a fluorometric analysis of neutral and polar lipids. Size-specific neutral lipid concentrations increased between body lengths of 2.0 - 6.6 millimeters (mm), but did not vary among worms > 6.6 mm. Because size-dependent changes in particle selection and del C-13 also diminish at ~6 mm, the combined data imply that a food-related bottleneck exists for juveniles < 6 mm. Once juveniles attain this size, they are able to forage as adults and are no longer subjected to the food limitation that existed earlier in development.

The documentation of ontogenetic diet changes and evidence of stage-specific food limitation suggest that variations in the supply of key juvenile foods (e.g. benthic diatoms or fresh phytodetritus) can impose recruitment bottlenecks that might be central to the dynamics of populations that deposit feed as adults and communities that deposit feeders dominate.

Geochemical Characteristics and Transport Processes of the Particulate Matter in the North Basin of Lake Lugano (Switzerland, Italy)

Hofmann, Annette. 1996
University of Geneva (Switzerland), 392 pp.

The north basin of Lake Lugano (Ticino, Switzerland), with a maximum depth of 288 meters (m), is permanently stratified. The water column is oxygenated above 80 m, suboxic between 80 and 100 m and anoxic below 100 m. The stratification built up during the twentieth century in response to anthropogenicaly induced eutrophication of the lake. The main focus of the thesis is the study of the dynamics of particles within this system. Through sampling of suspended particles and through sediment trap deployment, particle transport processes, precipitation-, mineralization- and dissolution processes between (1) the oxic- and anoxic layers, (2) the epilimnion, the hypolimnion and the bottom sediment, and (3) within the hypolimnion, were characterised. Sampling and measurements were performed on a regular basis between June 1992 and January 1994 at a pelagic sampling station (Gandria).

Most important in this study were the following results:
1) The geochemical cycle of Fe and Mn, confined to the suboxic zone, was markedly influenced by the spring input of labile organic matter originating from a diatom bloom. Oxyhydroxide precipitation was stimulated.
2) Particle aggregation was deduced from analysis of sediment trap fluxes and turbidity profiles. Observations concerned different particle size classes and water depths. In one case, model calculations could be applied. Results indicated high coagulation coefficients (0.1) for particles in the 1-2 micro m range.
3) Resuspension of particles was evaluated through Al fluxes in sediment traps. Focusing sensu stricto was identified.
4) Mineralization of organic matter, dissolution of authochtonous calcite and biogenic silica in the watercolumn were deduced from total fluxes of organic carbon, calcium and biogenic silica by taking in account resuspension fluxes. Maximal mineralization and dissolution fluxes were reached between 265 m and the lake bottom, due to longer residence times of particles in the benthic nepheloid layer (resuspension).
5) Mineralization of organic matter and dissolution of calcite in the hypolimnion seem to induce a slight progression of the chemical stratification of the watercolumn despite the considerable reduction of anthropogenic wastewater input to the lake since 1976.

The Role of Rivers and Lakes in the Transport of Organic Carbon and Carbon Dioxide

Hope, Diane. 1995
University of Aberdeen (Scotland), 186 pp.

A programme of field sampling was undertaken to quantify annual organic carbon fluxes at 23 sites from the headwaters to the lower reaches of the river Dee and river Don in northeastern Scotland. The annual fluxes of both dissolved organic carbon (DOC) and particulate organic carbon (POC) were found to increase downstream in both rivers. In headwaters and tributaries of the river Dee, annual DOC fluxes showed as much variation between catchments as seen in data from river systems worldwide and were positively related to the amount of wetland in the catchment area. This indicated that the size of the soil organic carbon pool was the single most important factor in determining annual riverine organic carbon fluxes. This hypothesis was tested by using archive information to estimate organic carbon exports for 85 large British rivers. The resulting flux estimates, along with data on soil organic carbon content were used to develop a predictive model of British riverine DOC fluxes. A model based on soil organic carbon storage and annual precipitation data from the catchments of 17 river systems was successful in explaining 94% of the variation in annual DOC fluxes between the sample catchments.

During the study, the potential importance of dissolved free carbon dioxide as an additional form of carbon transport in both rivers and lakes was highlighted. A direct method for measuring the partial pressure of carbon dioxide in freshwaters was also developed. Application of this methodology to samples from the river Dee and river Don indicated that free carbon dioxide in rivers may constitute an additional export equivalent to 10% of the annual organic carbon flux in British rivers. The relationship between dissolved carbon dioxide, DOC and watershed characteristics was further investigated in a study of 27 lakes in northern Wisconsin, the United States. The findings showed a significant positive correlation between the partial pressure of dissolved carbon dioxide, DOC, and the extent of wetland in catchments.

Overall the findings from this work have shown that lakes and rivers can act as important conduits for carbon transport (particularly from wetlands) both to the atmosphere and oceans. The link that has been established between soil carbon pools and riverine fluxes, should help to integrate rivers into future models of global carbon cycling. Furthermore, this work suggests that rivers (and lakes) may regulate increases in soil organic carbon pools induced by climate change.

Spatial Variance of Mobile Aquatic Organisms: Capelin and Cod in Coastal Newfoundland Waters

Horne, John K. 1995
Memorial University of Newfoundland (Canada), 185 pp.

Patchy distributions of organisms are a long-recognized attribute of terrestrial and aquatic ecosystems. Quantitative descriptions of spatial variance provide clues to processes that generate patchiness. In aquatic environments, greater effort has focused on quantifying spatial variance in distributions of plankton than on quantifying spatial variance in distributions of mobile organisms. To evaluate the relative importance of biological and physical processes that generate variance, a theoretical framework was developed that combines demographic, growth, and kinematic rates in dimensionless ratios. Ratio values are then plotted as a function of temporal and spatial scale in rate diagrams. Application of this technique identified kinematics as the dominant process influencing capelin (MALLOTUS VILLOSUS) distribution along the coast during the spawning season.

Hydroacoustic distribution data of capelin and Atlantic cod (GADUSMORHUA) were analyzed to examine how shoaling, schooling, and the aggregative response of predators contribute to the spatial variance of mobile, aquatic organisms. A characteristic scale of patchiness was not observed at the temporal scale of a single transect (about 1 hour) or at the scale of a survey (about 2 weeks). On average, spatial variance decreased slightly over intermediate scales (10 kilometers - 0.5 kilometer) and then dropped rapidly at smaller scales. Data manipulations and computer simulations demonstrated that shoaling potentially increases spatial variance at intermediate scales, and that schooling potentially reduces spatial variance at scales smaller than aggregation sizes. There was no evidence of an aggregative response by cod to concentrations of capelin throughout the analyzed scale range (20 meters - 10 kilometers). This unexpected lack of spatial association between predator and prey was explained using estimates of foraging energetics to show that cod were not constrained by physiology to track prey during the capelin spawning season.

Theoretical and empirical results of this study have increased knowledge of scale-dependent spatial variance in mobile, aquatic organisms and provided insight to the biological processes that potentially generate these patterns. Scale-dependent plots of spatial variance combined with rate diagrams can be used to evaluate the relative importance of biological and physical processes that influence organism dispersion as a function of spatial and temporal scale.

Ecosystem Dynamics of Protists and Bacteria in a Lotic Wetland Ecosystem

Johnson, Mark D. 1995
University of Alabama at Tuscaloosa (USA), 168 pp.

Despite their importance, little information is available on the ecology of protists and bacteria in freshwater wetland ecosystems. Microbial communities were compared monthly at eight sites in a lotic wetland within the coastal plain region of the southeastern United States, from upstream, through an alder swamp, reed marsh, and water lily pond, to a downstream site. Protist abundances and biomass, and bacterial abundances, biomass, and productivity were all generally greater in the wetland habitats compared to up stream and downstream sites, especially in summer. Among wetland habitats, planktonic microbial populations were most productive in the reed marsh and among submerged aquatic plants, and lowest in the alder swamp. The planktonic microbial communities were primarily heterotrophic. Dissolved organic carbon (DOC) derived from aquatic plant community production during summer in the wetland pond stimulated planktonic bacterial production, which served as a primary food source for protozoa. The wetland habitats affected the lotic system as a whole by substantially increasing the amount of microbial biomass transported downstream.

In the wetland pond, DOC concentrations, bacterial abundance and productivity, and protist abundance were more than an order of magnitude higher during warm months than cool months. Out-of-phase oscillations between microbial populations suggested protist grazing pressure strongly affected bacterial abundance during the warm months. Experiments using natural microbial communities showed similar uptake rates of macrophyte leachate by both grazed and ungrazed bacteria. However, in the plankton, grazing of bacteria by nanoflagellates resulted in greatly increased rates of carbon mineralization to carbon dioxide (CO2) rather than making this carbon available to other trophic levels.

OPHRYDIUM VERSATILE, a mixotrophic, colonial ciliate was studied to determine seasonal changes in its distribution, primary productivity, and rates of bacterivory. Summer rates of primary production and bacterial consumption were higher than any other season on the basis of colony surface area. However, high bacterial productivity and limited ciliate distribution diminished their importance to the pond ecosystem in summer. During the winter, these ciliates functioned primarily as bacterivores, and low planktonic bacterial productivity combined with a wide distribution of large ciliate colonies made O. VERSATILE capable of clearing up to one-third of the water column of bacterial production daily.

Spatio-Temporal Variations in Epiphytic Communities in Relation to Water Quality of the Delhi Segment of River Yamuna, and Experiments on the Patterns of Colonisation of Epiphyton on Natural and Artificial Substrates

Kaur, Parminder 1996
University of Delhi (India), 194 pp.

The epiphytic communities on the roots of water hyacinth of the river Yamuna (Delhi) were studied for a period of 24 months, together with physical and chemical variables, in relation to a pollution gradient. A total of 267 species of phyto-epiphyton were recorded (77 diatoms, 132 green algae, 32 blue-green algae, 22 euglenoids and 2 each of dinophyceae and chrysophyceae), within a seasonal succession characterised by dominance of diatoms with a shift in dominance to blue-green algae during summer. Among zoo-epiphyton, dominance ciliates shifts to peak of rotifers in summer. A combination of biotic indices (species diversity, richness) and multivariate analysis was employed to assess the impact of urban and industrial waste disposal on physical and chemical profile and biotic communities of the river. Results indicate that community dynamism is attenuated at the more polluted stations, concomittant with an increased predominance of a tolerant assemblage of diatoms and ciliated protozoans. Presence of bioindicator species have also been confirmed. The results presented will serve as a basis for subsequent studies relating to management and surveillance using epiphytic communities on natural and/or artificial substrates.

Phytoplankton in a Salinity-Alkalinity Series of Lakes in the Ethiopian Rift Valley

Kebede, Elizabeth 1996
Uppsala University (Sweden), 178 pp.

Phytoplankton species composition and biomass of 10 lakes were studied in relation to environmental variables, especially with respect to salinity and alkalinity. In addition, laboratory experiments were done on SPIRULINA PLATENSIS, the dominant phytoplankter in the saline, alkaline lakes. Growth response to variations in light, ionic composition, and salinity level were studied in continuous culture.

A total of 206 phytoplankton species/taxa were recorded from all lakes, in samples taken once during the short rains, in March-May 1991. The number of species declined as salinity and alkalinity increased in the series, reaching an almost unialgal population in Lake Chitu, the most saline (45 grams per liter salinity), alkaline lake in the series. Cyanophytes, chlorophytes, and diatoms were the most important groups in the lakes, and flagellated groups were not common. The most dilute Lake Koka (0.2 g/l salinity) had the highest species richness. There was no apparent relationship between phytoplankton biomass and salinity. In a seasonal study on Lake Awassa, three phases of thermal stratification and mixing were recognised. Increase in phytoplankton biomass was associated with inflow of nutrients and mixing during the rainy season. Seasonal variation in total biomass was relatively low (coefficient of variation < 20%). Phytoplankton production could be limited by nitrogen at the end of the dry season, during the stratification period, and by light, at least during the mixing periods.

SPIRULINA PLATENSIS isolated from Lake Chitu, showed a maximum specific growth rate of 1.78 per day at steady state, at about 330 micromol photons per square meter per second. The optimum nitrogen:phosphorus (N:P) ratio in cells was also reached at this irradiance level. Salinity stress with sodium salts showed that response in terms of growth rate and quantum yield was best in NaHCO3, less in NaCl, and least in Na2SO4.

Results from this study suggest that salinity-alkalinity, as well as inorganic turbidity and mixing depth affecting the light climate, play an especially important role in species composition and phytoplankton biomass of the Ethiopian lakes.

A Lotic Microcosm for Ecological and Ecotoxicological Studies on Benthic Macroinvertebrates

Khan, Muhammad I. 1995
University of London (United Kingdom), 148 pp.

An indoor artificial stream system was designed, developed and tested for consistency in behaviour of the system in terms of the kinetics of pollutant (copper) and the organisms contained in it over space and time.

Downstream drift of invertebrates in the system was found to be affected by intensity of light, flow rate, algal biomass in the system and by sublethal concentrations of copper. Bioaccumulation of copper as body burden was also analysed and found to be positively related to ambient copper level and negatively related to dry body weight in GAMMARUS PULEX and HYDROPSYCHE ANGUSTIPENNIS but not in SPHAERIUM sp.

Mortality analysis in terms of LC-50 values for GAMMARUS PULEX (L.) were also estimated in stream system and traditional tank toxicity method and were found to be more up to five times that in the tank system. Similarly LC-50's estimated using nominal concentrations were found to be double that calculated from integrated mean concentrations.

Downstream drift behaviour showed a decline in the magnitude of response after repeated pulses of sublethal doses while mortality was unaffected over the experimental time. Copper body burden showed a decrease as number of pulses of low concentration increased, but a gradual increase in copper body burden as number of pulses increased in higher concentrations.

Use of Stable Nitrogen Isotope Ratios to Characterize Food Web Structure and Organochlorine Accumulation in Subarctic Lakes in Yukon Territory, Alberta, Canada

Kidd, Karen A. 1996
University of Alberta (Canada), 193 pp.

Unusually high concentrations of persistent organochlorines were found in lake trout muscle and burbot liver from subarctic Lake Laberge, Yukon Territory. As a result of the elevated toxaphene concentrations in these fishes, a health advisory was issued by Health Canada in 1991, and the commercial, sport and subsistence fisheries on the lake were closed. Previous studies on Lake Laberge have revealed that the fish community structure is atypical when compared to other regional lakes, with high biomasses of burbot and longnose sucker and low biomasses of lake trout and lake whitefish. Likewise, the lake trout are known to be faster growing, fattier and strictly fish eating, unlike other populations from nearby lakes. It was hypothesized that the high concentrations of organochlorines in Laberge fishes were the result of an unusually long food chain in this lake, a factor that has been shown to affect the pollutant concentrations in fish from temperate lakes.

To characterize food web structure and examine the biomagnification of organochlorines through the food web of Lake Laberge and two reference lakes, Fox and Kusawa, fishes and invertebrates were analysed for stable nitrogen isotope ratios to quantify trophic position, and persistent organochlorines. Stable nitrogen isotope ratios were significant predictors of the organochlorine concentrations through these food chains and in the top predators from these lakes. The slopes of these regressions were greater for the more lipophilic organochlorines when compared to the less lipophilic organochlorines and appear to directly reflect a pollutant's potential to biomagnify through the food chain. Both within and among species, lipid content was a better predictor of the less lipophilic organochlorines such as hexachlorocyclohexane, while stable nitrogen isotope ratios were better predictors of the more lipophilic organochlorines such as PCBs and toxaphene. Lake trout and burbot from Lake Laberge fed at a significantly higher trophic position, as determined by stomach content analyses and stable nitrogen isotope ratios, than the same species from Fox and Kusawa lakes. The high concentrations of toxaphene in fishes from Laberge have been attributed to an unusually long food chain and not to elevated inputs of this pesticide.

Characterization and Prediction of Planktonic Nitrogenous Nutrition and New Production in Monterey Bay, California: Nutrient and Physiological Interactions

Kudela, Raphael M. 1995
University of Southern California (USA), 326 pp.

Recent interest in the importance of the global carbon cycle, especially with respect to "global warming," has resulted in renewed interest in a the study of new primary production. Historically, it has been recognized that as much as 50% of the production in the world's oceans occurs in eastern boundary current locales such as Monterey Bay, where this research was conducted. The fundamental goal of this research has been to evaluate two problems: first, whether the paradigm "nitrate uptake equals new production" still holds, and second, to determine whether it is desirable or even possible to separate the interrelated phenomena of primary and new production.

The shift-up model, expanded to include other substrates and interactions including silicate, carbon and light, provides a robust description of the associated rates and processes during upwelling. Rates of NO3, NH4 and urea uptake were measured, representing the first comprehensive annual study of phytoplankton nitrogenous utilization in a coastal upwelling regime. NO3 dominated throughout the year. Total N uptake demonstrated simultaneous uptake and the absence of obvious preference or competition for NO3 and NH4. Urea provided <10% of the total nitrogen (N) uptake, but became significant with low total N uptake rates. Strong seasonal patterns of nitrogen utilization, with maximal uptake rates and biomass accumulation occuring during active upwelling was followed by more oligotrophic conditions during non-upwelling periods.

Grow-out experiments demonstrated that NO3 is the most limiting factor controlling new production and biomass accumulation; silicate was a controlling, but not limiting, factor. Shift-up was readily induced, closely regulated by the NO3 concentration, and not a function of chlorophyll-A concentration or detritus; similarly, carbon:nitrogen (C:N) composition and utilization ratios demonstrated nitrogen limitation.

Coupling of C and N uptake rates and metabolism was observed in an upwelling plume, with both regulated by ambient light. C and N utilization were not balanced over the short time scales associated with upwelling. The observations agreed with the predictions of the shift-up model, with initially high levels of C utilization, increasing NO3 utilization (and decreased C uptake), and finally a return to high C utilization with a shift towards NH4 as a nitrogenous source. Diurnal patterns of C and N uptake were variable, emphasizing the need for caution in interpreting short-term incubations, or in assuming steady-state kinetics between C and N utilization.

A predictive model of new production which utilizes AVHRR imagery and the physiological (shift-up) results demonstrates that first principles of phytoplankton physiology may be used to determine new production. This model also provides insight into the underlying physiological responses associated with upwelling, and represents the first modeling effort to do so in depth.

A High-Resolution Paleoclimatic Record of a Closed-Basin Lake in the Northern Great Plains

Laird, Kathleen R. 1996
University of Minnesota (USA), 135 pp.

Climate dynamics have long been an area of scientific interest, and with the increase of anthropogenic-derived greenhouse gases, global climatic change has become a major scientific and political issue. Potential changes in water availability is a major concern, especially in drought-prone agricultural regions such as the northern Great Plains where even minor changes in climate could increase the frequency and severity of drought. In order to measure or predict possible anthropogenic influences on climate, we must first understand natural climatic variability. Proxy records of past climatic conditions can provide the long time series of data needed to establish these natural patterns.

Lakes are intricately linked to the hydrological system and can be sensitive recorders of climatic change. In semi-arid regions, biological remains preserved in the sediments of closed-basin lakes are a sensitive archive of past climatic changes. Fluctuations in the water budget within a closed-basin system are apparent as changes in lake level and in the ionic concentration and composition of the lake water. Diatoms are common members of the algal flora of inland saline and freshwater lakes and their distribution is highly-related to lake water salinity. Weighted-averaging regression techniques can be used to estimate salinity optima of diatom taxa from the analysis of modern diatom assemblages in surficial sediments of lakes spanning a salinity gradient. Using transfer functions, the estimated optima can then be used to infer salinity from diatom assemblages preserved in lake sediments.

Estimates of lake water salinity from fossil-diatom assemblages were used to infer past climatic conditions at Moon Lake, North Dakota, a climatically sensitive site in the northern Great Plains (NGP). The sensitivity of Moon Lake to fluctuations in climate was established by comparison of the estimated diatom-inferred salinity to known historical droughts derived from precipitation records for the past 100 years. Long-term climatic conditions were assessed at century-scale resolution during the Holocene period covering the last 11,000 years. This analysis provided a long-term perspective of climate in the NGP indicating that the Holocene can be described by four major hydrological periods. Further analyses at a multi-decadal resolution of the early-Holocene (10,000 to 7,000 years before present) suggests this period was more complex than previously thought.

In the drought-prone North American prairies high-resolution records of droughts are exceedingly sparse, with no proxy records longer than 500 years. The sub-decadal record of diatom-inferred salinity from Moon Lake for the past 2300 years indicated that extreme droughts of greater intensity than those during the Dust Bowl of the 1930's were more frequent before A.D. 1200. This suggests that the patterns of atmospheric circulation that produce drought today were more frequent and persistent in the past and that present-day climate records are not representative of long-term patterns of natural variation of drought intensity and frequency.

Although the Holocene has typically been thought to be a relatively stable period of climate, the diatom-based reconstruction of climatic conditions from Moon Lake indicates that distinct patterns of decadal- to centennial-scale fluctuations are evident during the Holocene. The high-resolution paleoclimatic record from Moon Lake provides valuable information on long-term climate that can additionally be used for evaluation of climate models.

Population Dynamics of Toothcarp (*Aphanius fasciatus* Nardo, 1827) in the Mesolongi and Etolikon Lagoons

Leonardos, Ioannis D. 1996
Aristotle University of Thessaloniki (Greece), 198 pp.

In the present study, the age, growth, reproduction and the population dynamics of APHANIUS FASCIATUS were investigated in three different sampling stations in Mesolongi and Etolikon lagoons. The age was determined from the scales and founded six age classes. The study of monthly marginal increment showed that APHANIUS FASCIATUS form their yearly annulus during February. Were founded significantly differences between sexes and between regions with relate to age composition, the slope of length-weight relationships, the mean back-calculated total lengths, the condition factor and the mortality rate. The reproduction season was particularly long. It began in April and ended in July. The spawning was multiple with the production of many clutches. The hydrated oocytes are relatively large with diameter about 2 millimeters and specific gravity 1.0046 grams per cubic centimeters, eggs are entangled in vegetation by means of long filaments. The study of fecundity showed that there are significantly differences between sampling stations, the maximum absolute fecundity was 591 eggs. The overall sex ratio was found 1: 2.44 (males: females) that was changing during the year.

Studies of Three Cell Cycle Proteins (PCNA, p34cdc2, and cyclin B) as Potential Cell Cycle Markers For Species-Specific Growth Rate Estimation of Marine Phytoplankton

Lin, Senjie. 1995
State University of New York at Stony Brook (USA), 335 pp.

Homologs of three cell cycle proteins, proliferating cell nuclear antigen (PCNA), p34cdc2, and cyclin B have been detected in marine phytoplankton. Their molecular masses were close to those observed previously in other organisms (PCNA=36 kiloDalton; p34cdc2=34 kDa; cyclin B=63kDa). In the species examined, they were all associated with active proliferation of the cell population, and decreased to undetectable levels in the stationary stage in the culture. The putative gene of PCNA was detected by northern and southern blotting in DUNALIELLA TERTIOLECTA and ISOCHRYSIS GALBANA with the molecular size of its mRNA being the same as PCNA mRNA in rat.

An immunofluorescence protocol was developed for marine phytoplankton. This protocol has been employed successfully for nuclear, chloroplastic, and cytoplasmic proteins as well as cell surface antigens in various species. It allows long-term sample storage at -20 degrees C and immunostaining at room temperature and thus is useful for both laboratory experiments and field investigations. Immunofluorescence using this protocol demonstrated that in the Chlorophytes D. TERTIOLECTA, and CHLORELLA AUTOTROPHICA, and diatom BACILLARIOPHYCEAE THALASSIOSIRA WEISSFLOGII, the PCNA homolog was located exclusively in the nucleus of the cell. In two other diatoms SKELETONEMA COSTATUM and ETHMODISCUS REX, the PCNA immunostaining was apparent in the chloroplasts as well as in the nucleus. Immunofluorescence also showed that PCNA in D. TERTIOLECTA was associated with the S phase of the cell cycle, a feature typical of PCNA in mammalian cells. In contrast, p34cdc2 was most abundant in G1/S and G2/M transitions, and least abundant when PCNA reached its peak.

Applying PCNA immunofluorescence to a growth rate model yielded estimates with an average overestimation of 33% for three species. When the model was modified, the accuracy of the estimation was significantly improved (<16% overestimation). Using the immunofluorescence method, the cell cycle was analyzed for a unculturable field-collected diatom E. REX, and a conservative estimate of growth rate was also obtained.

Attempts to purify PCNA from marine phytoplankton was partially successful on a small scale.

Effects of Sunlight on Organic Matter and Bacteria in Lakes

Lindell, Mans J. 1996
Lund University (Sweden), 135 pp.

This thesis examines the role of sunlight, specifically ultraviolet-B (UV-B) radiation (280-320 nanometers), on dissolved organic matter (DOM) and bacteria in lakes. Field experiments in lakes with different humic contents and geographical locations have been performed.

Photooxidation result in that part of DOM is oxidized to inorganic carbon (DIC), mainly carbon dioxide (CO2). The photooxidation rate can be of the same magnitude as respiration at lake surface on a sunny summer day. However, on a depth-integrated basis down 2 meters (m), respiration showed to be 3-12 times higher than photooxidation, as photooxidation is restricted to the surface. Simultaneously, DOM is photochemically transformed into more available forms to bacteria, thereby enhancing bacterial growth. Bacteria grew both in numbers and volumes, resulting in a several-fold increase in biomass when inoculated to sun-exposed sterile lake water.

However, bacteria are negatively affected by direct sunlight. As sunlight decreases with increasing depth, the attenuating compounds (humic acids) in the water act as a protective filter to organisms. Thus, bacterial production in a clear lake was negatively affected to 2 m depths, whereas in a humic lake negative effects were only recorded down to 0.2 m. In the investigated lakes, 10% of surface radiation values of UV-B was found at 55 centimeters (cm) in the clearest lake but only at 1.5 cm in the most humic lake. Photochemical effects on both bacteria and DOM occurred deeper than penetration of UV-B, suggesting that other wave lengths can be of importance. Even at the surface, UV-B plays a minor role in photochemical DIC-production (17%) compared to UV-A (39%) and PAR (44%). Photooxidation of DOM in lakes at different geographical places react equally to sunlight. However, within a lake, DOM exhibits seasonal variations, being most sensitive in spring and least sensitive at fall.

A balance between stimulation and suppression of bacteria in lakes exists. Bacteria are mainly inhibited during daytime, but may during night benefit from the photoproduced substances. As UV-B reaching the earth surface is likely to increase due to ozone depletion, and because CO2 is produced photochemically and indirectly by the stimulated bacterial growth, a link between ozone depletion and the "greenhouse effect" is suggested.

Impact of Size-Selective Predation on Lake Superior Crustacean Zooplankton by Lake Herring (*Coregonus artedi*)

Link, Jason S. 1995
Michigan Technological University (USA), 246 pp.

Samples from 1971 to 1993 demonstrated that the composition of the crustacean zooplankton community of Lake Superior has changed. Specifically, the abundance of large-bodied zooplankton has decreased significantly in the past two decades. Populations of a pelagic planktivore, the lake herring (COREGONUS ARTEDI), have concurrently increased, suggesting a process of selective predation. Examining the components of planktivory to elucidate this phenomena in a lake the scale of Superior, I assessed the encounter, pursuit, attack, capture and ingestion of zooplankton by lake herring. I stereoscopically videotaped lake herring feeding experiments to determine angles of elevation and bearing with reactive distance. Reactive volume, a novel approach, was calculated from these parameters; reactive volume addresses encounter, pursuit and attack for cruising pelagic fish. Capture success was also obtained from videotape analysis. I measured lake herring gill arches and zooplankton body dimensions to address retention. The probabilities associated with these steps of the planktivory process were combined in a model to predict stomach contents of lake herring. Validated with field caught lake herring, the model averages 80% accuracy, usefully simulates lake herring feeding behavior, and provides a basis for addressing numerous management and theoretical issues.

The Impact of Commercial Trawling on the Benthos of Strangford Lough

Magorrian, Bridgeen H. 1996
Queen's University of Belfast (Northern Ireland), 218 pp.

In recent years conflict has arisen between conservation groups and commercial fishing interests over perceived trawl damage to the benthic communities in Strangford Lough. Data from a number of survey techniques were combined to assess the impact of trawling on the benthos of the lough, principally on the diverse communities associated with the horse mussel, MODIOLUS MODIOLUS beds. The target species of the otter trawl fishery is the queen scallop, AEQUIPECTEN OPERCULARIS.

Fisheries data were recorded and a quantitative species bycatch list was compiled. The fishery is confined to a small number of local-based vessels and existing regulations seem adequate. Otter trawls with rollers (separated by discs) on the footrope were found to collect less bycatch, including notably fewer M. MODIOLUS, than trawls with a plain, continuous footrope.

The major bottom types and associated benthic communities present in the lough were mapped out using an acoustic bottom classification system, RoxAnn, in conjunction with underwater cameras. Visual data were statistically analysed to quantify the effects of trawling and certain benthic species were found to be significantly associated with M. MODIOLUS. Trawling was found to remove emergent epifauna and to reduce the structural complexity of the mussel bed, giving an overall flattened appearance. Grab sampling was used to further investigate the effects of trawling on benthic community structure, particularly the infaunal component of the benthos.

Side-scan sonar was employed to locate areas of the lough bed physically impacted by trawling. Otter boards were found to imprint distinct trawl marks on the lough bed and were identified on side-scan records. During the surveys a Geographical Information System (GIS) was successfully employed as a data management tool.

Based on this study, possible strategies for future management of the queen scallop fishery and Strangford Lough as a marine nature reserve have been discussed.

Effects of Pollution on Macrobenthic Invertebrates in Jakara Reservoir, Kano State, Nigeria

Mbagwu, Iheanyi G. 1995
Bayero University (Nigeria), 233 pp.

Multivariate analysis of benthic data, as major taxa, from a study of ecological impacts of pollution in Jakara reservoir showed that Axis 1 of NMDS ordination of the sampling sites accounted for 55.3% of the variation in spatial distribution of the organisms while Axes 2 and 3 accounted for 32.6% and 12.1% respectively. As genera, Axes 1, 2 and 3 accounted for 60.3%, 21% and 18.7% of the variation respectively. In both cases the sites exhibited a high degree of homogeneity in biotic distribution and the discrimination of the sites was not different.

The Coefficient of Multiple Determination (R2), of the Multiple Linear Regression of 11 environmental parameters upon the first 3 components of the ordination of the benthic data as major taxa indicated very high (0.81), average (0.41) and low (0.37) relationships between environmental parameters and the spatial distribution patterns. These coefficients are very highly significant ($p < 0.001$) and to them, P (48%), Water Content (40%) and Zn (68%) contributed highest respectively. Interpretations of these results implicated P as the most important source of sediment-related ecological stress and the order of importance of environmental factors in affecting the ecology of the reservoir was (1) factors related to nutrient enrichment from organic pollution, (2) factors related to the physical environment, and (3) factors related to toxic pollution.

Only Chironomids, Oligochaetes and Heleidae were found and these were dominated by CHIRONOMUS spp. (70%), TUBIFEX spp. (13%) and LIMNODRILUS spp. (4%). The 24 months of study were grouped into the annual rainy and dry season months or the low water and flood periods with respect to the seasonal distribution of the organisms which was found, through Principal Component Analysis, to be controlled mostly (45%) by the conductivity of the overlying water which remained at pollutant levels throughout. Annual mean density of benthos was 8469 organisms per square meter. About 0.7 centimeters (cm) of sediment, consisting of 59 to 80% clay and 20 to 30% silt is formed annually. The discontinuity layer was located between 1 and 6 cm and organisms, especially Oligochaetes, penetrated to these depths in some sites.

Annual mean input of P was 0.58 milligrams (mg) per liter. Application of the Vollenweider Relationship confirmed that the reservoir is hyper-eutrophic. Mean metal concentrations in water were: Zn, 0.145; Mn, 3.195; Hg, 0.607; Pb, 0.032; Cd, 0.005 and As, 0.005 mg per milliliter. Computed Risk Factors (RF), based on the US-EPA limits for safety of aquatic life, showed that Hg, Cd, Pb and Zn have RFs of 3,035, 125, 8 and 3 respectively. Mean metal concentration in the sediment were high: Zn, 1.122; Mn, 5.337; Hg, 0.984; Pb, 0.420; Cd, 0.047 and As, 0.078 milligrams per gram dry weight.

Restoration could be achieved through biological extraction of the pollutants in the inflow using Duckweed. It was estimated that if 3% of the annual run-off into the reservoir is subjected to a residence time of 10 days under a full cover of Duckweed, the levels of P in the water would be reduced to 0.08 mg per liter which is sufficient to restore the reservoir to oligotrophy.

Patterns of Spatial and Temporal Variability in Hawaiian Soft Bottom Benthos

McCarthy, Sheryl A. 1996
University of Hawaii (USA), 239 pp.

Temporal and spatial variability in shallow (10-20 meters), tropical, soft bottom communities of Mamala Bay, Hawaii were examined. The three objectives of the study were: (1) to determine if temporal variability (lunar periodicity and seasonality) exists in community structure and biomass of Hawaiian soft bottom benthos; (2) to examine the temporal nature of the benthic response to a freshwater runoff event; (3) to examine spatial variability in Hawaiian soft bottom benthos and its relationship to freshwater runoff. Benthic samples were obtained monthly for a period of twenty-five months to examine seasonal variations. Stations were more intensively sampled for a three-month period (every ten days) to examine lunar periodicity and the impact of a large runoff event. Small scale spatial variability was examined by comparing samples from the crest and trough of sedimentary ripples and from sand and rubble. Larger scale spatial patterns were examined during the summer (August 1993) and winter (February 1994) by sampling seven equally-spaced stations along a 3-kilometer (km) transect on the 10 meter (m) isobath leading east from a source of freshwater runoff, the Ala Wai Canal. Three additional stations (20 m) were sampled in February 1994 to examine depth-related changes.

The benthic communities were dominated by a few groups with significant temporal variations in density. Temporal dominance was especially evident in polychaetes (Syllidae and Pisionidae). Macrofauna densities ranged from 4,910 to 47,425 individuals per square meter with biomass ranging from 47 to 1091 milligrams per square meter. The dominant taxa, density and biomass of soft bottom communities were consistent with data from other shallow tropical and subtropical areas. There was no evidence that large wave events or freshwater runoff influences the density or community composition on short time scales. Significant within-month fluctuations in the density of major taxonomic groups existed, with evidence of lunar periodicity in the arthropods (primarily ostracods). There were significant between-year differences in density of macrofauna; it is possible this reflects a pattern spanning several years related to the 1991-1994 ENSO event.

Although the shallow, wave-swept sedimentary environment would be expected to produce a relatively homogenous biological community associated with the homogenous shifting sediments, small scale (< 30 m) differences exist between crest and trough of sedimentary ripple bedforms and between sand and rubble areas. Specifically, higher densities of syllids and copepods were associated with the crest of ripples. Higher densities, taxonomic richness and biomass were present within rubble. On a larger scale, along a 3.0-km transect eastward from the Ala Wai Canal, communities are similar with regards to density, biomass and dominance by motile, detritivorous and omnivorous polychaetes and motile, brooding crustaceans. In contrast, taxonomic diversity differed along the transect, with sites located near the mouth of the Ala Wai Canal, a source of freshwater runoff, consistently more diverse than Waikiki sites. There was no evidence that runoff from the Ala Wai Canal had a negative impact or was an important structuring mechanism for adjacent soft bottom shallow communities. The lack of impact could be related to the type of estuary examined, where little of the particulate matter was exported out of the system.

Seasonal Succession and Interannual Variability of Diatoms (Bacillariophyceae) from Saanich Inlet, British Columbia, in Relation to Seasonal and Climatic Factors

McQuoid, Melissa R. 1995
University of Victoria (Canada), 294 pp.

The purpose of this study was to examine effects of seasonal and climatic factors on diatom succession and interannual variability in Saanich Inlet, British Columbia. Frozen sediment cores were obtained and the laminae sampled to represent spring and summer seasons from light layers, and fall/winter seasons from dark layers for the years 1900 to 1991. Diatom stratigraphies were related to historical records of sea surface temperature, salinity, sea level, and the Pacific North American Index (PNA) using canonical correspondence analysis (CCA). Results indicate that laminae represent annual depositions and seasons could be defined by distinct species patterns. THALASSIOSIRA species were characteristic of early spring deposition. SKELETONEMA COSTATUM peaks confirm that summer samples follow the early spring bloom. RHIZOSOLENIA sp. was most abundant in fall/winter, dark samples. CCA showed that the environmental variables explained much of the variation in the diatom data and species of a particular season generally had optima for temperature and salinity characteristic of that time.

The role of environmental factors in seasonal succession was also examined by testing effects of various combinations of temperature and photoperiod on resting stage germination and cell division rates. Resting stages were induced in batch cultures using low nutrient media and a cold, dark period. A 3-factor ANOVA showed that species, temperature, photoperiod and their interactions significantly influenced germination time and division rate. Resting stages of CHAETOCEROS SIMILIS and ODONTELLA AURITA were most successful on warm, long days (20 degrees C/16 hours). CHAETOCEROS DIDYMUS and C. CINCTUS were most successful under more moderate conditions (15 degrees C/14 h),and DITYLUM BRIGHTWELLII germinated and divided rapidly under all conditions. The results were compared with environmental conditions prevailing during the presence of these species in Saanich Inlet. Favorable growth conditions determined for C. DIDYMUS, D. BRIGHTWELLII, and T. ROTULA were similar to conditions present when these species were commonly found in the fjord.

Several interannual changes were evident from the core data. The most notable is the cyclic pattern of variation in S. COSTATUM. This species showed highest peaks during periods of cold temperatures, such as cool ENSO cycles. The CCA indicates that changes in sea level and winter weather patterns may also play a role in diatom variations. Several littoral species had optima high on the PNA gradient, suggesting that they are more abundant in the sediments during times of heavy winter rains. The relationship between diatoms and sea level could be related to variations in nutrient supply to surface waters. Diatoms were also used to infer past water conditions in Saanich Inlet with weighted averaging regression and calibration. Results suggest that the diatom community underwent the greatest change in species composition during the 1930's and 1940's. Survival of diatom resting stages in cold/dark conditions supports the hypothesis that this life stage can provide a means of long-term survival for some species and may also represent an important component of the ecological memory of aquatic systems.

Sex in the Surf Zone: The Effect of Hydrodynamic Shear Stress on the Fertilization and Early Development of Free-Spawning Invertebrates

Mead, Kristina S. 1996
Stanford University (USA), 186 pp.

Many coastal marine invertebrates reproduce via external fertilization. Spawned gametes are exposed to the turbulence generated as waves break on the shore. This turbulence not only rapidly dilutes the gametes, but also mechanically damages them, and makes it difficult for the egg and sperm to come into contact. Eggs and sperm from 16 species of externally fertilizing invertebrates were exposed to environmentally relevant shear stresses in a Couette cell. This device consists of two concentric rotating cylinders that subject fluid between the cylinders to well-characterized shear stresses that recreate some aspects of surf zone turbulence. While all species tested (ALLOCENTROTUS FRAGILIS, COLOBOCENTROTUS ATRATUS, DENDRASTER EXCENTRICUS, ECHINOMETRA MATHEI, E. OBLONGA, LYTECHINUS PICTUS, STRONGYLOCENTROTUS PURPURATUS, TRIPNEUSTES GRATILLA, ASTERINA MINIATA, PISASTER OCHRACEOUS, CALLOISTOMA LIGATUM, HALIOTIS RUFESCENS, MYTILUS CALIFORNIANUS, M. GALLOPROVINCIALIS, ASCIDIA CERATODES, and URECHIS CAUPO) showed a decrease in fertilization success when exposed to shear stress, the magnitude of the decrease, and the shear stress at which the effect was apparent, varied among species. The gametes of some species were more susceptible to shear-induced damage than were others. The development of some species was delayed, or was abnormal, when fertilization occurred under moderate or high shear stresses. Many of the effects of shear stress are correlated with the wave exposure of the source population's habitat; others are probably related to a complex suite of structural features of the gametes.

The mechanisms by which shear stress affects fertilization and development were examined by performing fertilization experiments in a Couette cell under different velocity gradients and viscosities. Experiments with the purple sea urchin S. PURPURATUS showed that while shear stress (the product of the velocity gradient and the viscosity) governs fertilization success, velocity gradient is the primary factor affecting developmental success. Different suites of mechanisms fit these two patterns, and are thus implicated in either fertilization or development.

Field experiments with S. PURPURATUS indicate that surge channels, which are long, narrow topographical features of some coast lines, could serve as reproductive refuges for free-spawning invertebrates. Water containment and rapid mixing within the surge channel enable the eggs and sperm to come into contact, even when released meters apart. This increases fertilization success and is likely to influence the population structure.

Feeding Strategy of Calanoid Copepods of Different Trophic Levels in Two Areas of the Baltic Sea (Pomeranian Bight, Gotland Sea)

Meyer-Harms, Bettina. 1996
Rostock University (Germany), 180 pp.

The aim of the thesis was to analyze the feeding strategy of calanoid copepods in two areas of the Baltic Sea (Pomeranian Bight: PB, Gotland Sea: GS) which were characterized by different levels of eutrophication in the summer and early autumn.

The samples were analyzed using different methods: measurements of marker pigments (HPLC), cell counts using the Utermohl method, zooplankton counts and determination of d15N.

The main results of the thesis are summarized as follows. The copepods in the PB and in the GS exhibit different feeding strategies. Copepods in the PB, which has a mean phytoplankton biomass of 400 milligrams (mg) carbon (C) per liter feed selectively on crypto- and dinophyceae. In the GS, which has a mean biomass of 120 mg C per liter, feeding of copepods do not differ between the different phytoplankton groups. The assimilation efficiencies show that the ingested food was used increasingly less economically at high ingestion rates.

In the PB, feeding upon the primarily colonies-forming cyanobacteria was low. In contrast, in the GS, the ingestion of diazotrophic cyanobacteria probably depends on the physiological status of the bloom. It seems that at start of the bloom the cyanobacteria are hardly fed upon (2% of the cyanobacteria biomass, GS 1993). However, during the stationary and the regressing phase of the bloom, feeding on cyanobacteria increases considerably (20% of the cyanobacteria, GS 1994). 1.1% and 3.3% of the primary production were ingested by calanoid copepods in the PB and in the GS, respectively. In the nutrient limited system of the GS, 2.3 mg C per cubic meter per day were excreted by the copepods into the mixed layer.

The evaluation of the grazing experiments using cell counts and pigment measurements showed in the PB and the GS, that pigment analysis is a useful method to determine taxon-spezific ingestion rates by calanoid copepods. Pigment analysis enables good reproductible results to be obtained with a low time investment. Also, the variance is smaller when compared to that resulting from cell counts according to the Utermohl method.

The comparison between the chlorophyll-A-equivalents determined by chl-A/marker pigment ratios from algal cultures, and those determined by chl-A/marker pigment ratios from pigment measurement in the Pommeranian Bay and the GS, which were calculated by multiple regression analysis, showed that the estimation by multiple regression analysis is a good tool to consider the variation in the pigment composition caused by changing light conditions. The application of conversion factors gained from laboratory cultures is not recommended for the calculation of chl-A-equivalents from marker pigment concentrations in estuarine systems, which are characterized by variable light conditions due to horizontal and vertical mixing processes.

Temporal Dynamics and Regulation of Coastal Antarctic Phytoplankton Communities: Spring/Summer 1991-1994

Moline, Mark A. 1996
University of California at Santa Barbara (USA), 356 pp.

Previous studies in the Southern Ocean have documented the large spatial variability in phytoplankton biomass and productivity, with generally higher concentrations and rates associated with coastal regions and ice edge zones. The relatively low productivity, compared to lower latitudes, in nutrient rich pelagic waters is thought to be a result of light limitation through deep vertical mixing, decreased temperatures, and/or micronutrient limitation, however, the processes controlling phytoplankton dynamics are a subject of continual debate. As part of the Palmer Long-Term Ecological Research (LTER) program, the goals of this thesis are (1) to identify and quantify major factors regulating phytoplankton dynamics in an Antarctic coastal region and (2) to discern the shifting balance of these regulatory factors that determine variability in phytoplankton biomass, productivity and taxonomic composition. Unlike most studies undertaken in the Southern Ocean that are logistically restricted to spatial approaches, this study attempts to temporally define and quantify processes that underlie the natural variability in phytoplankton dynamics on time scales of hours to years.

The first three chapters detail the biological responses to physical forcing and nutrient dynamics during the 1991-92 season. Subseasonal fluctuations in sea ice, mixing depths, wind stress and advective processes were found to be the major driving forces affecting the timing, duration and demise of the local phytoplankton blooms. During a large diatom bloom, macronutrients were depleted to detection limits with significant shifts in nutrient ratios, timed to community composition change. A photophysiological index was identified and found to significantly track fluctuations in the in situ light field over a 30-fold change in integrated biomass. In combination with physical data, this index has the potential of assessing water column stability, which is identified throughout this study to be a major prerequisite for biomass accumulation. Peak timing and magnitude of daytime periodicities in photosynthesis varied on time scales less than a week, closely coupled to changes in phytoplankton community composition. High frequency sampling and consideration of diel periodicity were important when discerning differences between short time-scale variability and long-term trends in primary production.

In chapter 4, the interannual variability in biomass and associated productivity in this coastal environment was comparable to variability within years. Despite this variability, the replacement of one phytoplankton group by another was similar on subseasonal time scales for all 3 years. Results suggest that monitoring phytoplankton successional patterns may be a more sensitive marker for detecting long-term changes in Southern Ocean ecosystems than either biomass or productivity indices. The final chapter examines the temporal distribution of inorganic nutrients and utilization by phytoplankton. Seasonal mean nitrogen:phosphorus:silicon ratios agreed well with previous work, however, occasionally indicated disproportionate uptake by phytoplankton depending on the taxonomic composition. While nutrient concentrations set the maximum potential for photosynthesis/chlorophyll-A, growth rates remained high, suggesting nutrients were non-limiting.

Regional Distribution of Primary Production in the North Sea Simulated by a Three-Dimensional Model

Moll, Andreas. 1995
University of Hamburg (Germany), 151 pp.

A biological one-dimensional water column model for the simulation of the annual cycles of the phytoplankton dynamics and a physical transport model are coupled into a three-dimensional primary production model to estimate the annual primary production of the North Sea and its regional differences.

The simulations are driven with actual forcing, taking into account monthly river loads from 14 rivers, daily velocities and diffusivities from a baroclinic North Sea model, and solar radiation calculated every 30 minutes. The high variability of the forcing generates a considerable variability in the physical and biological dynamics.

The simulated annual cycles of chlorophyll, phosphate and daily net primary production are validated with available data from different years in the sense that the simulated single year can be compared to the measured variability. Such comparisons show that the simulation reproduces the general features of annual phytoplankton cycles in terms of chlorophyll and the triggering nutrient phosphate. This establishes confidence in the calculated annual primary production of the North Sea.

The simulation of 1986 yields an integrated annual water column net production ranging between 92 and 345 grams carbon per square meter per year for the different regions. The annual production agrees quite well with the general quantitative knowledge of the total yearly production, except for the British coast where the production is overestimated due to lacking inorganic suspended matter attenuation.

Zooplankton Development in Plussee: Invertebrate Predation in the Context of a Biomanipulation Experiment and Long-Term Trends

Mumm, Heike. 1996
University of Kiel (Germany), 156 pp.

In the framework of a joint 3-year biomanipulation programme carried out in different lake types, factors influencing the development of the zooplankton community in a stratified eutrophic lake was assessed. ARIMA intervention analysis was used to estimate long term effects and the effect of reduced planktivorous fish predation. A new type of in situ enclosure experiments was used to test if gape-limited predation by the invertebrate predator CHAOBORUS FLAVICANS could compensate size-selective predation by fish and whether the lack of large herbivores in Plussee could be attributed to strong fish predation. In 2 x 2 factorial experiments carried out in 2 different seasons of 3 successive years the differential impact of invertebrate predation and competition by large-sized laboratory-grown DAPHNIA on the plankton was tested.

The intervention analysis showed that the calanoid EUDIAPTOMUS and the rotifer ASPLANCHNA increased within the last decade whereas the cladocerans DIAPHANOSOMA and CERIODAPHNIA decreased in number. The reduced fish predation during the biomanipulation period did not result in an increase of DAPHNIA number as predicted by the Size Efficiency Hypothesis. However the number of the invertebrate predators CHAOBORUS and LEPTODORA increased as expected according to the Cascading Trophic Interactions Hypothesis. Despite the fact that DIAPHANOSOMA was a preferred prey of CHAOBORUS in the enclosure experiments, they increased in number in the course of the biomanipulation using temporal windows.

In the enclosure experiments CHAOBORUS was important for the structure and size distribution of the plankton. The large sized laboratory grown DAPHNIA survived in the enclosures. They were reduced by CHAOBORUS while the biggest naturally occurring daphnid D. LONGISPINA was least influenced among the cladocerans. The strongest impact of CHAOBORUS was found on small sized cladocerans like DIAPHANOSOMA and CERIODAPHNIA. The competition effect of the large DAPHNIA was low. The impact of CHAOBORUS on the zooplankton cascaded down to the phytoplankton when the predator prey pair ASPLANCHNA and CERATIUM was present. In the absence of CHAOBORUS invertebrate predation could be taken over by CYCLOPS.

It is generally believed that the impact of fish and invertebrates on zooplankton differs in that fish causes a shift to smaller body sizes whereas invertebrates do the opposite. This was not the case for the different cladoceran taxa in Plussee. The influence on size distribution and life history parameters depended on how the preferred prey sizes of the predators related to the possible body size range of the prey.

Biogeochemistry of Newly Created Riparian Wetlands: Evaluation of Water Quality Changes and Soil Development

Nairn, Robert W. 1996
Ohio State University (USA), 279 pp.

Biogeochemical development of created riparian wetlands was investigated in full-scale systems and replicated mesocosms. Water quality changes and soil development were evaluated over two years in two newly created freshwater marshes (1 hectare each) with similar hydrology. One wetland was planted; the other received no planted vegetation. Wetlands received pumped river water impacted by nonpoint source pollution. Hydrologic budgets were dominated by pumped surface flows (mean inflow = 1480 cubic meters per day). Two floods accounted for 32% of inflow in 1995. Both wetlands significantly decreased turbidity (62 to 27 NTU) and increased dissolved oxygen (9 to 11 millgrams/liter).

Inflow soluble reactive phosphorus (SRP) and total phosphorus (TP) concentrations (17 +/- 3 and 169 +/- 11 micrograms P/ liter) were significantly higher ($p<0.05$) than outflow concentrations (SRP: 5 +/- 1 and 6 +/- 1 micrograms P/ liter; TP: 69 +/- 8 and 74 +/- 9 micrograms P/ liter for planted and unplanted wetlands, respectively). Mean removal rates were 1.0 gram P /square meter /year for SRP and 5.4 grams P /square meter /year for TP and did not differ significantly between wetlands ($p<0.05$). Approximately 40% of TP mass removal occurred during two floods. A conservative tracer (Cl) indicated limited dilution. Flow and concentration did not affect P removal which was loading-limited and seasonal.

Soil submergence resulted in physicochemical changes indicating hydric soil genesis. Deposition and decomposition of algal mats affected biogeochemical development, resulting in muck layers (1-15 centimeters) in both wetlands. Soil organic C increased significantly to 2.21 +/- 0.11% for planted and 1.88 +/- 0.11% for unplanted wetlands and differed significantly ($p<0.05$). Retention of allochthonous sediments and P, coupled with autochthonous production by algae, increased soil Ca, Fe, P and C. Planted vegetation development demonstrated little effect on biogeochemistry over the first two years.

In 20 mesocosms (0.9 square meter), soil effects (hydric or non-hydric) on wetland development were studied. Submergence resulted in initial convergence of soil physicochemical attributes. Growth and elemental composition of SCIRPUS TABERNAEMONTANI exhibited no distinct differences due to soil type, although the hydric soil exhibited a viable seed bank.

Interaction of Pelagic Harpacticoid Copepods and the Colonial Marine Cyanobacterium *Trichodesmium* Spp.

O'Neil, Judith M. 1995
University of Maryland (USA), 180 pp.

TRICHODESMIUM is a filamentous, colonial nitrogen- fixing cyanobacterium, ubiquitous in tropical and subtropical regions of the world's oceans. As a nitrogen-fixing organism,TRICHODESMIUM has the potential to introduce "new" nitrogen (N) to oligotrophic systems which are generally regarded to be N-limited. TRICHODESMIUM often forms extensive blooms and can comprise a significant fraction of total primary production in oceanic surface waters. Therefore, the consumption and fate of TRICHODESMIUM has important consequences for understanding carbon (C) and N cycling in the open ocean. The one confirmed grazer of TRICHODESMIUM is the pelagic harpacticoid copepod MACROSETELLA GRACILIS. M. GRACILIS has a pan-global distribution and has evolved a very specific association with TRICHODESMIUM. M.GRACILIS uses TRICHODESMIUM as a physical substrate for juvenile development, as well as a food source.

Experiments were conducted to assess TRICHODESMIUM ingestion, assimilation and ammonium regeneration by M. GRACILIS and other pelagic copepods. Experiments were conducted aboard ship at sites within the Atlantic, Pacific and Indian Oceans. Several different types of pelagic copepods (calanoids, harpacticoids and a poecilostomatoid species), were tested for ingestion of TRICHODESMIUM by labelling the cyanobacteria photosynthetically with C-14. The only copepods capable of ingesting TRICHODESMIUM were the three pelagic harpacticoid species tested: M. GRACILIS , MIRACIA EFFERATA and OCULOSETELLA GRACILIS. These harpacticoids were able to graze >75% of their weight in C/day in TRICHODESMIUM. There were no significant differences at the $p < 0.05$ level (ANOVA) between ingestion rates determined in the Atlantic, Pacific and Indian Oceans. In the Caribbean, M. GRACILIS showed higher ingestion rates of T. ERYTHRAEUM than T. THIEBAUTII. This may be due to the presence of a neurotoxin in T. THIEBAUTII which may be an important factor in determining trophodynamic interactions. M. GRACILIS and M. EFFERATA showed resistance to the T. THIEBAUTII toxin at concentrations well above those lethal to calanoid and poecilostomatoid species tested.

M. GRACILIS not only ingested, but rapidly incorporated ingested TRICHODESMIUM. Approximately ~22-38% of the TRICHODESMIUM C ingested was incorporated. This was determined by following the metabolic partitioning and incorporation of C-14 labelled TRICHODESMIUM into copepod lipids, polysaccharide and low molecular weight compounds using sequential biochemical fractionation. The rapid transfer of N fixed by TRICHODESMIUM to M. GRACILIS was demonstrated in the Caribbean by use of 15N2-labelled T. thiebautii. Rates indicated that M. GRACILIS could consume 33-45% of total colony N per day and >100% of new N fixed/colony /day. Experiments investigating ammonium regeneration by M. GRACILIS using N-15 isotope dilution, indicated that the rate of ammonium release increased as both copepod numbers and food availability increased. M. GRACILIS, through excretion and possible mechanical breakage of cells while grazing, appears to provide a direct link between atmospherically derived "new" N from TRICHODESMIUM and regenerated ammonium in tropical and subtropical oceans.

Stable Nitrogen Isotopes in Adirondack Forest and Aquatic Ecosystems

Owen, Jeffrey S. 1995
State University of New York,
College of Environmental Science & Forestry (USA), 128 pp.

The nitrogen cycle was studied in selected Adirondack northern hardwood forest and lake ecosystems using a 15N natural abundance and a low level enrichment approach. The three forest study sites (Woods Lake, Pancake-Hall, and Huntington Forest) differed in N availability. The relationship between 15N natural abundance and N availability was investigated. Within a site, delta (del) 15N values in plant tissues were lower than observed for soils. Del 15N values of soil increased with depth. Comparisons of 15N natural abundance of soil and plant tissues among the sites were consistent with the hypothesis that higher del 15N values were associated with greater N availability.

In two Adirondack lakes (Dart's and Arbutus) that differed in nitrate concentration, del 15N values of seston and sediment were compared. In Arbutus Lake, seston del 15N values averaged 2.5 per thousand (mil) and 2.7 per mil at 2 and 6 meters depth, respectively. In Dart's Lake, seston del 15N values averaged 1.3 and 1.1 per mil at 6 and 14 meters depth.

In the epilimnion of Arbutus Lake, nitrate concentrations were generally low (range 0 to 13 microeq/liter) with decreased nitrate concentration during the the summer; summer seston del 15N and water column nitrate concentrations were inversely correlated ($r=-0.82$, $p=0.011$). In Dart's Lake, where concentrations were higher (range 12.9 to 22.4 microeq/L) and the magnitude of spring depletion lower, there was no significant correlation between seston del 15N and nitrate concentration. These observations support the hypothesis that differences in seston del 15N values were related to differences in relative utilization of nitrate between these lakes.

Paleoindicators of Changing Water Conditions in Louisiana Estuaries

Parsons, Michael L. 1996
Louisiana State University (USA), 316 pp.

Sediment cores were collected to study the development of eutrophication and hydrological changes in coastal Louisiana. The cores were taken at marsh sites hypothesized to be influenced primarily by riverine inputs (Fourleague Bay-FLB), localized activities (Terrebonne Bay-TSMP), and both riverine and localized processes (Airplane Lake-APL). The sediment cores represented time frames ranging from 330 years (APL) to 70 years (TSMP) BP according to core dating results.

Sediment core samples were analyzed for diatoms, other microfossils, pigments, biogenic silica, and sediment characteristics. Additionally, land use records were utilized as a proxy of anthropogenic activities, and to aid in the interpretation of the paleoindicators. Analysis of the data indicated that eutrophication developed at all three sites since the 1950's, most rapidly since the early 1970's, and was directly related to fertilizer use in the region. The diatom community changed over time, reflecting a species shift towards smaller, more lightly silicified forms in response to growing eutrophication. A diatom-based trophic index, biogenic silica measurements, sediment chlorophyll-A content, and several diatom species were the paleoindicators that most strongly responded to the development of eutrophication at the three sites.

A diatom-based salinity index displayed trends similar to long-term salinity measurements taken in the region. Salinities decreased at the FLB and APL sites, in response to increased river discharge, whereas salinities increased at the TSMP site, probably due to the construction of the Houma Navigation Canal. Increased water levels, observed through tide gauge measurements around coastal Louisiana, were not evident in this study.

Several acute events left signals in the sediment, including Hurricane Andrew and the flood of 1927. Although several events were evident, they were generally distinctive enough to have no effect on the eutrophication and hydrology studies. A canonical discriminant transform function was derived from analysis of a sediment layer left by Hurricane Andrew, which was shown to be reworked sediment displaying characteristics of the surrounding freshwater, estuarine, and marine environments. This transform function was standardized to distinguish preserved event horizons in any coastal sedimentary environment, although further development and refinement is needed before the function can be utilized elsewhere.

Detection and Characterization of the Sewage Plume at Sand Island, Hawaii

Petrenko, Anne A. 1997.
University of Southern California (USA), 249 pp.

The sewage plume resulting from the discharge of treated municipal waste water from the Sand Island Treatment Plant diffuser in Mamala Bay, Oahu, Hawaii was detected and mapped during a September 25 - October 1, 1994 cruise. The three main objectives of the study were to: (1) detect the plume and calculate its initial dilution; (2) optically characterize the plume; and (3) determine the plume dynamics.

The sewage plume was detected unambiguously in situ and in real-time by its high beam attenuation coefficient at 660 nanometers (nm) and its low salinity signatures. The plume was generally located west of the diffuser, spreading along the isobaths due to the forcing of the dominant currents. Identical but weaker signatures located deeper than the plume were interpreted as "old" plumes, relative to more recently discharged waste water with stronger signatures. The initial dilution of the plume was calculated using temperature/salinity diagrams and by plotting initial mixing lines between discharged effluent and ambient waters. The initial dilution was low (always below 250:1) compared to the dilution expected for surfacing plumes (at least 1000:1). These low dilutions were due to the trapping of the plume at depth, caused by an unusual temperature stratification of the water column during the cruise.

The optical characteristics of the plume included increases in absorption and beam attenuation coefficients, and increases in ultra-violet fluorescence relative to ambient waters. Fluorescence for the excitation/emission pair 228nm/340nm was associated with both recent and old plumes, but not with phytoplankton, and was interpreted as tryptophan-like fluorescence. This signal should be further investigated as a potential in situ waste water tracer.

Strong temporal variability in the temperature stratification was reflected in the plume dynamics. Oscillations in plume depth revealed the vertical forcing by an internal tide propagating westward along-shore. This type of physical process is generally not accounted for in three-dimensional circulation models and could explain discrepancies between in situ observations and plume modeling results. This vertical forcing by internal tides could lead to unpredicted contamination of sediments or surface waters.

The Role of Microbial Food Webs in Benthic-Pelagic Coupling in Freshwater and Marine Ecosystems

Pile, Adele J. 1996
College of William and Mary (USA), 161 pp.

A majority of carbon in freshwater and marine ecosystems is in the form of ultraplankton, heterotrophic and autotrophic plankton < 5 microns including heterotrophic bacteria, PROCHLOROCOCCUS, cyanobacteria, and autotrophic eucaryotes. However, ultraplankton and subsequently microbial food webs have yet to be incorporated into models of benthic-pelagic coupling despite the preponderance of macroinvertebrates with the capacity to feed on ultraplankton. I have examined the role of microbial food webs in benthic-pelagic coupling in three ecosystems: Lake Baikal, Siberia, Russia; the Gulf of Maine, the northwest Atlantic Ocean; and Conch Reef, the Florida Keys, the United States. Using sponges as a model organism and in situ measurements, I have quantified (1) suspension feeding on ultraplankton and (2) release of dissolved inorganic nitrogen (DIN) and phosphorus (DIP) resulting in direct evidence that benthic macroinvertebrates do occupy the level of primary consumer within the microbial food web.

Dual-beam flow cytometry was employed to quantify sponge suspension feeding on five types of ultraplankton: heterotrophic bacteria, SYNECHOCOCCUS-type cyanobacteria, autotrophic picoplankton < 3 microns, autotrophic eucaryotes 3-10 microns, and in marine ecosystems PROCHLOROCOCCUS. Grazing by the freshwater sponges BAIKALOSPONGIA INTERMEDIA and B. BACILLIFERIA and the boreal marine sponge, MYCALE LINGUA, was unselective for all types of ultraplankton with efficiencies ranging from 63-99%. This is the first time that grazing on SYNECHOCOCCUS-type cyanobacteria and PROCHLOROCOCCUS by macroinvertebrates has been quantified in freshwater and marine ecosystems. Conversely, the coral reef sponges IRCINIA FELIX and I. STROBILINA release significant amounts of DIN and DIP as a result of grazing on procaryotic plankton. Using a general model for organism-mediated fluxes, it is conservatively estimated that through active suspension feeding sponges in Lake Baikal retain 1.97 grams carbon (C) per square meter per day while M. LINGUA retains 29 milligrams C per square meter per day while at Conch Reef sponges released 150 micromol DIN per square meter per day and 48 micromol DIP per square meter per day. A majority of the carbon retained at all three locations was from procaryotic cell types suggesting that ultraplankton are an important overlooked component of benthic-pelagic coupling.

Fractionation, Characterization and Dynamic of the Dissolved Phophorus in Amazonian Waters

Pinheiro, Patricia R. de C. 1996
National Institute of Amazonian Fish (Brazil), 121 pp.

Investigations of the distribution and flux of phosphorus (P) among the compartments using radioisotope tracers, selective filtration and gel chromatography have provided an insight into the general nature of the epilimnetic P cycle in lakes. Under P-limited conditions, enzymatic hydrolysis and ultraviolet (UV) mediated photo-oxidation of dissolved organic phosphorus (DOP) are important rate-limiting processes in the P cycle. The objective of this study was to investigate the dynamics of P in flood plain lakes and rivers in the Amazon River Basin near Manaus, Brazil. Radioisotope tracers, selective filtration, ultrafiltration and gel chromotagraphy were used to characterize the different components of P and their dynamics in these systems. Laboratory assays were also used to charactize the lability of different DOP fractions to enzymatic hydrolysis and UV photo-oxidation.

When carrier-free 32P was added to surface waters from Lago Camaleao, a flood plain lake associated with the Solimoes River, the labeled P fractionated slowly (12 hours) into 4 distinct P compartments: a particulate P pool (>0.2millimeters, 83%), a phosphate pool (9.4%), a high molecular weight DOP component (~66,000 Da, 7.3%) and a very high molecular weight DOP component (>200,000 Da, 0.3%). The accumulation of activity in the PP pool was greatest in the 0.2-1 millimeter-size fraction suggesting that bacterial uptake may control the flux between the PO4 and PP pools. Turnover times for P in the PO4 pool ranged from 8.3-11.1 hours. Enzymatic hydrolysis of DOP was found to occur in both lakes and rivers.and the low molecular weight fractions (<1,000) appeared to be more susceptable to hydrolysis. Significant levels of ultraviolet-mediated photo-oxidation was only encountered in the Negro River and only in the DOP fraction from 1,000 - 30,000 Da.

The dynamics of P in Amazon flood plain lakes and rivers is apparently quite different from that encountered in glacial lake basins of the north temperate zone. The long turnover rates encountered for phosphate in Lago Camaleao, suggest that P may not be as limiting in it is in north temperate lakes. Seasonal inputs of P-rich waters and sediments from the Solimoes River may help to reduce P-limitation in this case. The DOP compounds in these tropical flood plain lakes and rivers also appear to be much larger and more refractory. This may reflect the predominance of refractory terrestrially derived organic matter in these riverine environments. Photo-oxidation of POD appears to occur only in high DOC systems such as the Negro River.

Spatial and Temporal Structure of Limnetic Entomostraca (Crustacea) in E.R. Mexia Reservoir (Neuquen and Rio Negro Provinces, Argentine)

Puig, Alba 1992
Buenos Aires University (Argentina), 180 pp.

The variability of plankton in reservoirs is still little known, mainly in those lake-like. Planktonic crustacean species structure was studied in the E.R. Mexia norpatagonic lake-like reservoir (39 degrees 30' South; 69 degrees West; A= 820 square kilometers; zmean= 25 meters; RT= 1 year). Temporal and macrospatial variations in number and biomass were also estimated and related with some environmental factors. The defined structural and phenologic model was contrasted with that of other lakes and reservoirs. Extensive samplings were carried out in the Limay River (to which the reservoir belongs) and the Neuquen River subbasins. Monthly vertical profiles in one sampling station (October 80 - March 83), and vertical hauls between bottom and surface were accomplished in six limnetic stations (November 83 - October 84) of the reservoir with an "ad hoc" developed sampler, with nets and flowmeter.

Changes in specific composition of the Limay River were evident from the upper end of the reservoir up to the rest of the river. The species registered in the reservoir were those with higher dispersion degree in the studied subbasins. The reservoir species number (8) was similar to those of temperate lakes. It corresponds to a "copepod environment,"of BOECKELLA GRACILIS type. The reservoir taxocenosis showed high biocenotic resemblance with that of a glacial lake, similar in retention time and latitude. The mean annual biomass showed slight variations in three years and it agreed with the oligo-mesotrophic state established through classic parameters. Longitudinal gradients in density means (in area basis) of planktonic crustacean species and in turbidity (mainly inorganic) averages were observed. A gradient in primary productivity means (in area basis) was also inferred. Since predation doesn't seem to be responsible for these crustacean gradients, it is proposed that they would be linked to direct and indirect effects of the turbidity gradient. The temporal variation in density and in community structure exceeded the spatial one. The main change in community structure was displayed during summer due to an increased importance of cladocerans.

The Role of Fecal Pellets in the Flux of Carbon to the Sea Floor on a River-Influenced Continental Shelf Subject to Hypoxia

Qureshi, Naureen A. 1995
Louisiana State University (USA), 255 pp.

The Louisiana continental shelf near the Mississippi and Atchfalaya River deltas is stratified and highly productive coastal system characterized by the largest hypoxic (dissolved oxygen < 2 milligrams per liter) zone in the western Atlantic Ocean. Carbon export from surface waters in the form of sedimenting zooplankton fecal pellets was examined to determine its importance in the formation and maintenance of oxygen deficiency in the bottom waters.

Two sediment traps (5-6 and 15 meters) were deployed in 1991 and 1992 in 20 meter water depth within an area of chronic and seasonally severe hypoxia. I determined the fecal pellet number and carbon flux, and total carbon flux from the surface waters, the percent primary production exported as fecal pellets, and the potential for fluxed fecal pellets to support bottom water hypoxia. I also quantitatively sampled the water column at discrete depths for fecal pellets and zooplankton to determine potential source organisms and their seasonal, diel and spatial variation.

The highest densities of total organisms, copepods, and copepod nauplii occurred during March and April (1992), when chlorophyll-A concentrations in surface waters were highest, and decreased in summer and fall. The abundance of fecal pellets was positively correlated with total organisms, copepods, and copepod nauplii: the likely source of fecal pellets.

The fluxes of total particulate material, organic carbon, organic nitrogen, fecal pellet carbon, and phytoplankton carbon varied similarly between seasons, and was lowest in summer and highest in the spring. The fluxes were greater in 1991 than in 1992. Seasonal variations in fecal pellet number and carbon flux were positively correlated with indicators of high surface water productivity in 1991, but not in 1992. The flux of fecal pellets from surface to bottom waters accounted for 55% of the particulate material exported vertically, exceeded phytoplankton carbon fluxes, and was high enough to deplete the bottom water oxygen reserves in spring.

The results support the hypothesis that the development of summer hypoxia is associated with the decomposition of organic matter accumulated in spring primarily by the sedimentation of phytoplankton bloom via fecal pellets, and not as intact phytoplankton cells.

Sublethal UV-Effects and UV-Adaptations in *Daphnia*

Rhode, Stephan C. 1996
Ludwig-Maximilian University (Germany), 150 pp.

Ultraviolet-B (UV-B) radiation has increased quickly in a short evolutionary time span due to the decrease of the ozone layer. Information about UV-avoidance strategies and their costs is, in addition to direct UV effects on organisms, an important key to understanding UV radiation as a selective ecological factor and to predicting influences of increasing UV radiation on the biosphere. My goal was to quantify factors determining UV-penetration depth and to characterize and quantify the benefit and cost of pigmentation and downward migration in the genus DAPHNIA as a model for UV-avoidance strategies in zooplankton.

Spectral UV radiation was measured in 9 lakes of different trophic states and an empirical model was developed to predict spectral attenuation coefficients based on the secchi depth and photometrical measurements. The influence of ozone, sun angle, altitude, albedo, and trophic state on the UV-penetration depth was analyzed.

Spectral UV attenuation in exuviae of melanized and transparent D. PULEX clones was measured. UV transmittance was significantly higher in the transparent clone (85%) than in weakly (19%) and strongly melanized clones (8%). The benefit of the pigmentation was quantified as the distance that a pigmented daphnia could stay higher in the water column under the protection of the melanized carapax in contrast to a transparent carapax. The distance, calculated on the basis of the above-mentioned empirical model, ranged from 0.2 m to 5.7 meters, depending on the grade of pigmentation and the trophic state of the water.

I tested UV-induced depth selection behaviour of unpigmented and pigmented DAPHNIA species in microcosms with a radiation and temperature gradient. All experiments showed a significant downward migration of UV-exposed daphnids into the colder part of the microcosms. Exposed daphnids avoided UV radiation by downward migration in spite of the anticipated cost of a colder environment. Unpigmented D. GALEATA, D. PULEX and D. PULEX OBTUSA showed a stronger UV response than D. ROSEA with carotenoids and a melanized D. PULEX clone did. The pigmentation allows the organisms to stay closer to the surface under UV radiation, and thereby reduces the cost (i.e., reduced growth rate in colder temperatures) of UV-induced downward migration.

The cost of melanin pigmentation was quantified in life table experiments, and feeding experiments with SALVELINUS SALVELINUS as a predator. Melanized DAPHNIA PULEX clones had lower intrinsic growth rates. The intermediate melanized clone showed an intermediate growth rate. In addition, predation risk was 1.1 to 2.5 times higher for melanized daphnids, depending on the size-class of the prey.

Buoyancy and Vertical Movements of Marine Planktonic Diatoms

Richardson, Tammi L. 1996
Dalhousie University (Canada), 146 pp.

The effects of light and nutrients on the buoyancy of marine planktonic diatoms and the potential biogeochemical consequences of vertical movements of diatoms in coastal and open ocean ecosystems were examined. A study of a relatively small coastal diatom (THALASSIOSIRA WEISSFLOGII) in an experimental water column showed that under nitrate-replete conditions, T. WEISSFLOGII grew rapidly and exhibited nearly-neutral buoyancy, but that cells sank after depletion of ambient nitrate. Experiments showed that increased carbohydrate ballast in nitrate-depleted cells may have caused the increased sinking of cells in the tank, and that reversion of chemical composition upon re-introduction of nitrate can result in detectable increases in cell buoyancy. The biogeochemical consequences of nutrient-dependent changes in sinking rates of small diatoms include increased residence time of cells in the mixed layer of the ocean and enhanced transport of deep nutrients to the euphotic zone uncoupled from inputs of inorganic carbon.

Time-course experiments involving the large, buoyant diatom RHIZOSOLENIA FORMOSA examined changes in chemical composition and buoyancy during nitrate-replete growth, nitrogen-starvation, and recovery. Cells could maintain unbalanced growth for at least 53 hours after depletion of ambient nitrate. Increases in carbon:nitrogen (C:N) and carbohydrate: protein ratios observed during N-depletion reversed upon re-introduction of nitrate to culture medium. Buoyancy was related to nutrition: upon N-depletion, the percentage of positively buoyant cells decreased, but increased within 12 hours of nitrate re-addition. RHIZOSOLENIA FORMOSA took up nitrate in the dark at rates three times their N-specific growth rate, indicating the potential for luxury consumption of nitrate that can be stored for later use in N-depleted surface waters. These results are consistent with purported vertical migrations of RHIZOSOLENIA in nature. Cells may survive fairly long periods in N-depleted surface waters and will continue to take up carbon, then can resume nitrate uptake and will become more buoyant upon returning to deep water sources of N.

The potential contributions of migrations of RHIZOSOLENIA to open ocean new production were examined using a numerical model that predicted fluxes of carbon and nitrogen during a steady state migration cycle, specific rates of increase of biomass, total migration cycle times, and vertical distributions. Modelled fluxes of particulate organic carbon (POC) and particulate organic nitrogen (PON) normalized to integrated water column abundance were used to derive a factor which was then combined with literature estimates of RHIZOSOLENIA abundance to predict fluxes of POC and PON. New production estimated by the model was on order of 0.033 millimoles N square meter per day; this value represents at most 17% of new production that results from turbulent diffusive fluxes of nitrate into the euphotic zone.

Mercury Transfer as a Descriptor of the Hydrological Functioning (River - Aquifer Exchange) of the Upper Rhine Flood Plain in Alsace, France

Roeck, Ute 1992
Louis Pasteur University at Strasbourg (France), 252 pp.

Mercury (Hg) levels in 4 aquatic moss species (Bryophytes) from the hydrological system of the Alsatian Rhine flood plain in northeastern France (canalized Rhine, its main tributary, the Ill River with a functional flood plain, and groundwater-fed stream network) were analyzed. The location of the sampling sites was based on results obtained in former studies (Krause & Carbiener 1975, Carbiener 1977, Carbiener & Ortscheit 1987, Carbiener & Trmolires 1990) using different approaches of water quality investigation and river-aquifer interaction (hydrological tracer : Cl- ; physico-chemical parameters: (NO3- , PO43- , NH4+); phytosociological bioindication scale based on river macrophyte communities).

Characteristic differences in Hg contents in the aquatic bryophytes from the groundwater-fed streams were detected. Higher annual average Hg contents in the aquatic bryophytes up to 0.29 gram (g) Hg/g (dry weight) from the groundwater-fed streams reflected river seepage sectors which are all located close to the canalized Rhine. Low level zones with Hg contents < 0,05 g Hg/g (dw) indicated non-contaminated and drained sectors of the alluvial groundwater table. The most vulnerable sectors of the riparian alluvial aquifer close to the Rhine River, not only with regard to the historical Hg pollution, but also for chronic contamination, especially with persistent pollutants, are the sectors upstream from the hydroelectric power plants and the river bent sectors. The hydrostatic pressure of the water column leads to the infiltration of contaminated river water through the gravel bed of the Rhine, which shows high hydraulic conductivity, into the riparian aquifer.

By contrast with the canalized Rhine, the Ill River, also highly contaminated by mercury, does not show river seepage. When it is flooding, this river imports water of high quality into its aquifer. The functional flood plain of this river, due to the soil-vegetation-system, purifies the flood water : the vegetation absorbs nutrients and the soil colloids (clay, limon) adsorb cations (Sanchez-Perez et al. 1991), and thus mercury. The results of this study confirm the impact of river canalization on river-aquifer exchange activities and thus the rule of the preservation, and, perhaps, restoration, of functional flood plain systems for alluvial groundwater-quality.

Stratification and Mixing in Hypersaline Mono Lake, California

Romero, Jose R. 1996
University of California at Santa Barbara (USA), 238 pp.

Application of a one-dimensional (1D) vertical mixing model to hypersaline (about 94 grams per liter) Mono Lake during 1 year reproduced mixed-layer dynamics well, but hypolimnetic heating was underestimated. One possible source of hypolimnetic heating is vertical mixing by methane bubble plumes rising from the sediments. Simulations with the inclusion of a bubble plume algorithm required an ebullition rate 300 times greater than the maximum estimate to simulate observed hypolimnetic heating.

The influence of lake level and salinity changes on seasonal mixing was modeled with the 1D model where the diffusivity was based on the Lake Number (LN). The simulation reproduced salinity dynamics well for 2 years of monomixis and 6 years of meromixis. Assuming climate change causes less precipitation, the frequency and duration of meromixis for 100, 87.5, and 75% of the freshwater inputs over a 50-year period (1940-1990) was simulatedwith the assumption of no stream flow diversion. Simulations indicate the lake is susceptible to meromixis over a large lake level range for all scenarios during large runoff years.

The effect of freshwater inputs on stratification, vertical mixing, and upward ammonia flux was evaluated during a 6-year (1989-1994) monomictic period. Five years had falling lake level and periods of inverse salinity stratification with double diffusive salt fingering conditions during the last several months of thermal stratification. Bi-weekly to monthly summer (June-September) vertical diffusivity estimates in the thermocline from the heat-flux gradient method ranged from 9.5x10(-7) square meters per second during wet 1993 to 4.2x10(-6) meters per second during a drought in 1989. Estimated seasonal and interannual differences in the upward ammonia flux can be partly explained by variations in freshwater inputs and wind forcing.

The 1D model simulated mixed-layer dynamics adequately for 5 years from 1989-1994. The destabilizing influence of inverse salinity stratification resulted in the inapplicability of the 1D assumption during 1989. During the other 5-year modeled diffusivities within the pycnocline were underestimated by 10-20 times. Three approaches were tested to increase mixing: (1) sub-daily wind speed input, (2) benthic boundary layer turbulence, and (3) the LN as an index of mixing. The LN parameterization yielded the best results and suggests boundary mixing along the margins and perhaps shear mixing in the interior during high wind forcing predominate as the major vertical transport mechanisms.

Characterization of Microbial Activities of the Microbial Communities in the Littoral Zone of Lake Constance

Sala, Ma. Montserrat. 1995
Autonomous University of Barcelona (Spain), 246 pp.

A main characteristic of the littoral zone of lakes is the increased concentration of organic matter due to autochthonous production (phytoplankton, phytobenthos, macrophytes) and allochthonous inputs of terrestrial origin. Bacteria as the primary users of this organic matter play an important role in its degradation and following conversion into bacterial biomass. The main part of the organic matter present in aquatic ecosystems is found in a polymeric form which cannot be directly absorbed by the cells without previously undergoing enzymatic hydrolisis. For this purpose, bacteria produce specific ectoenzymes and their activity is an indicator of the quality of the substrates undergoing hydrolization. The main purpose of this study was to evaluate the microbial degradation of the different substrates in the littoral zone of Lake Constance (water and sediment) and to compare them with the degradation in pelagic waters. In order to interprete the field results, several experiments were carried out in the laboratory. It was followed the production of different ectoenzymes used in the degradation of the main natural substrates found in the lake. This was done by adding each carbon source to lake samples. The sources were living algae, crustacean zooplankton, and detritus of macrophytes, algae, tree leaves and chitin. Living algae enriched the medium with small carbohydrates released by the cells, while crustacean zooplankton, due to algal grazing, contributed larger carbohydrates of algal origin, and chitin from their exoeskeleton. Microbial communities (bacteria and protozoa) growing on vegetal detritus exhibited a successional composition and a succession of ectoenzymatic activities. First, there was a hydrolisis of small molecules and nonstructural carbohydrates (starch) which was followed by the hydrolisis of structural polysaccharides (cellulose and hemicellulose). This process ocurred more rapidly in the case of the autochtonous substrates (algae and macrophytes) than in allochtonous substrates (leaves).

Higher temperatures and the presence of protozooans in the samples caused an increase in the speed of the succession. Bacterioplankton was present in similar concentrations in both the epilimnion of the pelagic and the littoral waters of the lake. However, the bacteria of the latter exhibited increased activities and production. Bacterial activities in the littoral water also showed a higher range, due to the frequent resuspension of the sediment caused by strong winds. The mixing caused by storms helped to decrease the high heterogenity found in the littoral sediments. The microbial communities present in these sediments showed higher rates of polysaccharide hydrolysis during the period of senescence of macrophytes and higher plants. The annual mean of ectoenzymatic activities were between one and two orders of magnitude higher than those found in the water, however the specific activities (activity per cell) were much lower in the sediment. The microbial communities living in the littoral zone of Lake Constance showed higher activities of hydrolysis of polymeric substrates, presumably due to the higher input of organic matter in this zone.

The Inshore Fish Populations of Lake Kariba with Reference to the Biology of *Synodontis zambezensis* Peters, 1852

Sanyanga, Rudo A. 1996
Stockholm University (Sweden), 115 pp.

Standard gill net survey date on the distribution and abundance of the inshore fishes of Lake Kariba along the Zimbabwe shore showed that the Mochokid SYNODONTIS ZAMBEZENSIS (squeaker) contributed 40% of the total catch (fresh weight). Special emphasis is placed on analysis of biological data of this catfish, which unlike the other inshore fishes, inhabits deep as well as shallow waters and has increased in abundance since the establishment of the lake. Results also showed that S. ZAMBEZENSIS as well as some smaller species such as BRYCINUS LATERALIS, BARBUS UNITAENIATUS and PSEUDOCRENILABRUS PHILANDER contributed significantly in terms of index of relative importance (IRI). Along the shore between fished and unfished areas, species relative abundance was found to be more or less the same but mean lengths of species caught in commencial nets were significantly lower in the fished areas.

The abundance of S. ZAMBENZENSIS was seasonally correlated (0.78). Seasonal depth changes in distribution were observed and a peak in abundance occurred in April in the shallower waters. Size distribution was however inversely related to depth, with the largest squeakers occurring in the 0-3 meter depth zone. Oxygen depletion in the hypolimnion and breeding behaviour seem to cause the seasonal migration that affected distribution.

Aspects of fish stock assessment such as fecundity, growth and mortality were evaluated for S. ZAMBEZENSIS. Selectivity analysis showed that the gear used (Lundgren monofilament gill nets) for sampling covered the whole population size range enabling the data to be used for growth analysis. There were no large differences in growth parameter results obtained using LFA and vertebrae growth rings. The L-Infinity (L-i) for males is 33.6 centimeters (cm) and 31.1 cm, and L-i for females is 38.3 and 38.2 cm respectively, while the K values are 0.19 and 0.21 males, and 0.24 and 0.26 for females. S. ZAMBEZENSIS females were found to be very fecund and attained fifty percent maturity (L-50%) when they are around three years of age. The breeding activity for males was very low, never exceeding 10% throughout the year and as a result they never attained a fifty percent maturity, as shown on the maturity ogive where the L-50% length was beyond the L-i.

Stomach contents analysis confirmed that S. ZAMBEZENSIS is euryphagous and fed on the benthos as well as the surface water depending on the availability of preferred food. It is an omnivorous species, preferring the gastropod Lymnaea Natalensis (59% IRI) and Chironomidae larvae (33% IRI) mostly. S. ZAMBEZENSIS diet is elastic, evidence showed that it switched its preferred food to certain insects and this was related to the emergence of those insects. Fish and plants were fortuitous in the diet.

The concept of biological interaction between species, covering predation and food consumption were modelled for Lake Kariba using ECOPATH II. All findings pointed to a large biomass of S. ZAMBEZENSIS which is very much under-exploited commercially. Hence its low total mortality of 0.55 - 0.86 per year.

Results from the study suggest that the observed pattern of distribution and size is due to a complex interaction of biotic factors such as food distribution and abiotic factors such as oxygen and rise in water level. In conclusion, the success of S. ZAMBEZENSIS was attributed to its wide niche, increase in gastropod populations, anti-predatory mechanisms and currently negligible fishing mortality.

The Nutrition of Two Cladocerans, the Predaceous *Bythotrephes cederstroemi* and the Herbivorous *Daphnia pulicaria*

Schulz, Kimberly L. 1996
University of Michigan (USA), 212 pp.

In this dissertation I investigated the nutrition of a carnivorous cladoceran, BYTHOTREPHES CEDERSTROEMI, using both an energetics and a nutrient cycling perspective, and the nutrition of the related herbivorous cladoceran, DAPHNIA PULICARIA(for which energetics are well-understood), from a nutrient cycling perspective. First, radioisotopes were used to measure the bioenergetic parameters ingestion and assimilation for BYTHOTREPHES CEDERSTROEMI fed DAPHNIA PULICARIA, helmeted D. GALEATA MENDOTAE, or unhelmeted D. GALEATA MENDOTAE. B. CEDERSTROEMI were found to ingest 50-60% of a DAPHNIA prey and to assimilate 60-65% of the ingested prey tissue. The helmet of D. GALEATA MENDOTAE did not interfere with the feeding process. These feeding efficiencies, in combination with recent diet analyses and fish behavior studies, imply that the invasion of B. CEDERSTROEMI into Lake Michigan should result in a two-fold decrease in energy transfer to large fish.

Next, the relative carbon:nitrogen:phosphorus (C:N:P) ratios of BYTHOTREPHES CEDERSTROEMI, BOSMINA LONGIROSTRIS, calanoid copepods, cyclopoid copepods and copepod nauplii were determined. Copepod nauplii differed sharply in elemental composition from adults, having the lowest C:P values of any taxon tested. The phosphorus levels found in B. CEDERSTROEMI indicate that cladocera and copepod nauplii should be the highest quality food, consistent with the results of previous diet choice studies.

Finally, changes in DAPHNIA PULICARIA nutritional status were evaluated in response to manipulations of the N:P loading ratio. The regression of dry weight to ash weight ratio versus body length differed for nitrogen and phosphorus-limited DAPHNIA and served as a useful proxy for nutritional status of D. PULICARIA. Mineral limitation was found to depress fecundity, growth and survivorship of D. PULICARIA, but phytoplankton and bacterial growth rates indicated that feedbacks present in more complicated systems may be mediating this limitation and need to be quantified further. This study demonstrates that both energetics and nutrient dynamic approaches can be useful for answering specific questions about individual organisms and for making predictions about how these organisms will interact with other trophic levels.

Changes within the Zooplankton Community as a Consequence of Extreme Biomanipulation: The Role of the Invertebrate Predator *Chaoborus*

Sell, Anne F. 1996
University of Technology at Dresden (Germany), 121 pp.

In biomanipulation, the abundance of planktivorous fish is artificially reduced in order to increase the abundance and grazing activity of herbivorous zooplankton. In a small lake at Graefenhain, Germany, the stocking of piscivorous fish lead to an almost complete elimination of planktivorous fish and to subsequent changes in the zooplankton community. Small cladocerans were replaced by two large-bodied daphnids (DAPHNIA ROSEA and D. PULEX). Simultaneously, the predatory invertebrate CHAOBORUS (CH. FLAVICANS and CH. OBSCURIPES) increased to densities as high as 10 larvae per liter. I investigated the role of CHAOBORUS in the absence of planktivorous fish and its impact as part of a trophic cascade.

Comparing the manipulated lake with a non-manipulated reference lake, I investigated the changes in species compositon of the cladocerean community. In a field experiment within the manipulated lake, I used a newly developed type of enclosure to examine the impact of CHAOBORUS predation on DAPHNIA and on phytoplankton development. Adults of both DAPHNIA species realized a "size-escape" from the gape-limited invertebrate predator by growing to sizes too large to be ingested by CHAOBORUS. The juvenile instars of DAPHNIA spp. were morphologically protected by neckteeth which were only produced in the presence of CHAOBORUS. Nevertheless, CHAOBORUS could be shown to account for severe mortality in DAPHNIA spp. D. ROSEA were found to be more vulnerable, and in turn were strongly favored in enclosures without CHAOBORUS. On the final sampling date, the mean daphnid abundance (+/- standard deviation) in three replicate enclosures with ambient densities of CHAOBORUS was 1.8 +/- 0.6 individuals (ind) per liter, whereas 67.9 +/- 3.9 ind/liter were present in three bags without the invertebrate predator. Phytoplankton and chlorophyll-A concentrations were markedly reduced in enclosures from which the invertebrate predator was excluded. Secchi transparency increased to 4.85 +/- 0.03 meters (m) in the bags without CHAOBORUS, compared to 1.80 +/- 0.37 m in the presence of the predator. Thus, the experiments showed that severe reductions in the abundance of planktivorous fish can allow increasing abundance of an invertebrate predator to numbers which strongly suppress even large, morphologically-defended DAPHNIA and thereby limit grazing impacts on phytoplankton density and water clarity.

Further investigations focused on the mechanisms allowing for competitive coexistence of DAPHNIA PULEX and D. ROSEA. Individuals of D. PULEX showed an increased ability to produce hemoglobin in summer, which enabled them to tolerate an oxygen-depleted medium. Vertical distribution in the water column led to an almost complete spatial separation of the two species. D.PULEX amounted to less than 10% of all daphnids in the surface layer and to more than 96% of all individuals in the metalimnetic low oxygen layer. The D. PULEX were able to maintain high birth rates while Hb appeared to allow them to exploit food resources in the metalimnion.

Phosphorus Cycling Model Study in Xiamen Western Sea, China

Shang, Shaoling. 1995
Xiamen University (China), 101 pp.

A dynamic box model was attempted in the study of phosphorus cycling in Xiamen Western Sea.

State variables involved in the model were dissolved inorganic phosphorus (DIP), dissolved organic phosphorus (DOP), particulate phosphorus (PP) and biomass of phytoplankton. The evolution of the state variables were considered to be controlled by physical transport, external inputs, and biogeochemical processes. Physical transport was caused by residual current and eddy diffusion. External inputs included benthic flux, atmospheric deposition, loading from Jiulong River and sewage discharge. The central point of biogeochemical processes was plankton activities, including phytoplankton photosynthesis, respiration and secretion, and zooplankton grazing and excretion. Plankton mortality, organic matter mineralization and sinking of phytoplankton and detritus were accounted for as well.

The above processes were parameterized and synthesized into a cycling model of phosphorus. The model was run for a period of two months from March to May, 1994. When compared to the field data, the computed dynamics of DIP, DOP, PP and phytoplankton biomass appeared generally realistic. However, some of the distribution features could not be reproduced, partly due to the simplified description of the behaviour of zooplankton and organic matter, and the unknown influence of aquaculture.

Successful simulation meant that the model contained the most important processes and the parameterization of these processes were reasonable. Therefore, the significance of such a kind of modeling study was first shown in methodology. Furthermore, flowing rates of phosphorus between the functional compartments were obtained, giving quantitative views of phosphorus cycling in the study area. Benthic flux was shown to be an important source of phosphorus in this area. It was also indicated that heavier sewage discharge or weakened tidal dispersion might be dangerous most possibly in the north part of Xiamen Western Sea. Future models might be improved once rich data and better knowledge about biogeochemical processes were obtained.

Biological Assessment of Water Quality in the Rivers of Nepal

Sharma, Subodh. 1996
University of Agriculture, Forestry and
Renewable Natural Resources at Vienna (Austria), 398 pp.

To develop a biological method in river water quality classification for Nepal is the main aim of the present research. With this goal in mind, 178 sites were sampled including 106 rivers, 5 ponds, 3 lakes, and 3 canals.

This research covers nearly all ecoregions with an altitudinal variation of 80 meters in the south to 3802 meters to the north above sea level and provides important faunistic informations. The biological assessment method adapted for Nepal combines the Central European System and the BMWP/ASPT method used in UK.

The Central European principles governing the saprobic water quality classes is found suitable also for Nepal. Four main water quality classes defined were "none to very slightly polluted" (oligosaprobic), "slightly polluted" (oligosaprobic to beta-mesosaprobic), "moderately polluted" (beta-mesosaprobic), "critically polluted" (beta-mesosaprobic to polysaprobic) and "extremely polluted" (polysaprobic). The classes are designated in Roman numericals from I to IV and differentiated in colours such as blue, green, yellow, and red according to the increasing degree of saprobity.

After an extensive application of ten different biotic index and score methods, a new system was adopted for Nepal called as Nepalese Biotic Score and abbreviated as NEPBIOS. NEPBIOS contains the following information: (1) number of family-level indicator organisms added; (2) score values of the family-level indicator organisms modified; (3) higher taxonomic precision is obtained.

In aggregate 82 families of macrozoobenthos are scored. Some genera of mayflies, water beetles, stoneflies, and chironomids are additionally scored. Some important improvement in NEPBIOS is done with some recommendations for satisfactory application of the system.

With the development of this system, the water resources authorities in Nepal have now in their hand a fast and cheap informative instrument useful for water quality monitoring.

Acidification Influence on the Balance of Production and Decomposition in the Small Lakes of Karelian Isthmus

Shirenko, Larisa A. 1995
Russian Academy of Sciences at St. Petersburg (Russia), 120 pp.

The Karelian Isthmus, including a lake district of about 15 000 square kilometers in area, is situated between the Baltic Sea and Ladoga Lake (northwestern Russia). Hydrochemical examination of the small lakes in this region have indicated extensive anthropogenic acidification.

The impacts of acidification on lake ecosystems have been characterized, mainly based on the bacterial components aquatic food webs and the balance of primary production and destruction. In several acid lakes, decreasing density of bacterial population and bacterial activity (bacterial productivity and destruction, respiration per cell) were noticed. The ratio of primary production to destruction decreased with decreasing pH.

An in situ enclosure experiment was performed in a Krasnoye lake to examine the effect of acidification on density of bacteria, diversity of phytoplankton, several bacterial rates and balance of primary production and destruction. The diversity of phytoplankton, the density of bacterial population as well as the ratio of primary production to destruction decreased with increasing acidity. There were no differences in the morphological type or mean volume of the bacterial cells. Bacterial production and destruction were at the same level as at pH 6.4, but at pH 4.0, 5.4 bacterial activity was lower. Respiration per bacterial cell was lower in all acidified enclosures than in the control.

In addition, phosphatase activity of bacteria was determined. The estimation of activity of bacterial phosphatase permits the estimation of biochemical activity of lake water connected with bacteria. Acidification was the primary cause for the strong depletion biochemical activity of lake water. It is possible that the decrease in activity of bacterial phosphatase is one of the mechanisms potentially leading to oligotrophication of acidified lakes as a result of phosphorus deficiency.

The Role of Biochemical Self-Purification Process on the Fate of Pollutants and Water Quality in Lake Ladoga Basin

Slotina, Svetlana E. 1994
Russian Academy of Sciences at St. Petersburg (Russia), 218 pp.

Lake Ladoga is one of the northernmost great lakes of the world and a source of drinking water for a great part of north-western Russia, including St. Petersburg with a population of six million people. There are about 500 enterprises in the basin of Lake Ladoga and their waste waters contain about 600 different chemicals of which more than 300 are toxic. The number of chemicals produced is continuously increasing.

Lake Ladoga ecosystem is subjected to persistent contamination by heavy metals, oil products, and other xenobiotics. The contaminants are actively involved into migration cycles, finally find their way and accumulate in different compartments of the lake's ecosystem. According to our data, up to 53% of metals entering the lake are retained there as a result of sedimentation (accumulation coefficients 102-106).

Among different factors which influence the water self-purification process of Lake Ladoga, the biological degradability of organic pollutants is the one of the generally-regulated criteria determining their fate in natural water. It is usually evaluated as 5 or 20 days biochemical oxygen demand (BOD). We have studied the influence of natural (pH, microorganisms, eutrophication etc.) and anthropogenic (organic and nonorganic compounds, heavy metals etc.) interaction on the BOD values. Significant effect of the pollutants with different chemical structure on the biochemical oxygen demand process was determined. The base of our method is the quantitative proportion between the toxicity of the metal ions and their chemical structure described by the physico-chemical properties. In the experiments on some hydrobionts (in particular, DAPHNIA MAGNA) the data on the toxicity for DAPHNIA MAGNA of such metals as Pb, Hg, Cu, Co, Cd, Zn were obtained. A quantitative description of log 1/LC50 values by means of covalent characteristic (C) was obtained (r=0.8).

Thus the northern geographical location of Lake Ladoga, climatic, hydrological, and hydrobiological characteristics of aquatic ecosystem, high degree of pollution cause relatively low intensity of biological and biochemical processes in the lake.

Phosphorus Cycling in the Lake Mendota Ecosystem: Internal Versus External Nutrient Supply

Soranno, Patricia A. 1995
University of Wisconsin at Madison (USA), 157 pp.

In most north temperate lakes such as Lake Mendota, Wisconsin, phosphorus (P) often limits primary productivity. The largest source of P to the lake is the watershed. When P loads to the lake are large, blue-green algae (cyano-bacteria) dominate and form nuisance blooms. My overall research goals were to identify linkages between factors that occur at the landscape scale with factors that occur at the scale of algae. My specific research objectives were to: (1) develop a spatially explicit model to quantify the effect of land use change on annual P loading; (2) compare the relative contribution of internal and external P sources to Lake Mendota's epilimnetic P-budget during summer; and (3) determine the predictability of blue-green algal blooms at the daily scale in Lake Mendota.

In collaboration with others, I developed a simple model to estimate nonpoint-source P loading from land to water using geographic information system (GIS) databases. The model has only three parameters and accounts for the distribution of land uses with distance from open water. The greatest contribution to loading was found to come from a heterogeneous riparian corridor that surrounds the lake and streams. The width of this corridor varies among years depending on annual precipitation. This concept of a "variable source area" has rarely been applied to P loading in large watersheds, and yet may provide a useful framework for examining the importance of landscape features on characteristics of surface waters.

Because internal sources of P in lakes can also be large and variable, I compared internal and external loads to the epilimnion of Lake Mendota during two summers. Internal loading in deep, stratified lakes occurs through two major mechanisms: hypolimnetic entrainment of P across the thermocline and epilimnetic sediment release. Although loading from entrainment has been suggested to be large, it can be difficult to characterize. I developed a method to measure the input of P that occurs by entrainment using continuous temperature profiles measured with thermistors attached to a buoy and a datalogger. Internal loading from hypolimnetic entrainment made up a large part of the P budget during both years, and was about 8 times larger than external loading during an average loading year.

However, because algae respond to environmental fluctuations at time lags ranging from 1 - 15 days, I examined the response of blue-green algae to internal and external P supply and environmental variables at the daily scale in Lake Mendota during summer 1993. Surface blooms occurred every 20 - 30 days, and lasted from 1 - 3 days. My results show that blue-green algal dynamics are not predictable at the daily scale. In addition, water column chlorophyll concentrations and surface bloom occurrence were not strongly related. This is important because water column chlorophyll is commonly measured and predicted using water quality models, but it is surface blooms that are perceived by the public and need to be managed.

Optical Properties of the Marine Cyanobacteria *Trichodesmium*: Applications to Remote Sensing

Subramaniam, Ajit. 1995
State University of New York at Stony Brook (USA), 180 pp.

TRICHODESMIUM spp. are nitrogen-fixing marine cyanobacteria that are frequently the most abundant phytoplankton in tropical oligotrophic waters. This study calculated that TRICHODESMIUM supply the Northern Caribbean Sea 4.1 x 10 (+9) grams nitrogen/day via nitrogen fixation, more than any other source of new nitrogen there. The importance of the role TRICHODESMIUM play in the world oceans can be assessed using satellite imagery, but this requires algorithms that can distinguish TRICHODESMIUM from other phytoplankton.

The absorption properties of TRICHODESMIUM are key to developing a remote-sensing algorithm. But there are discrepancies in reports in the literature of their absorption spectra. This study, using measurements of absorption, fluorescence and oxygen evolution action spectra, determined that the discrepancies were due to real physiological variability and hypothesizes a new model to explain the variability. TRICHODESMIUM was found to change the ratio of phycourobilins to phycoerythrobilins to adapt to the available light, demonstrating state transitions in nature. Under high light, near the surface around noon for example, light absorbed by phycourobilin was not transferred to Photosystem II, increasing fluorescence around 565 nanometers (nm). Therefore, algorithms for detecting TRICHODESMIUM need to incorporate low absorption around 550 nm and high fluorescence at 565 nm.

A remote-sensing reflectance model was developed using measured backscattering and absorption spectra. The measurements of chlorophyll-specific absorption showed that "secondary packaging," the effect of self-shading in colonial phytoplankton, was an important factor in quantifying TRICHODESMIUM chlorophyll biomass. This study calculated an underestimation by at least a factor of 4 of TRICHODESMIUM chlorophyll biomass by standard satellite chlorophyll (chl) algorithms. The model results showed that the combination of the high backscatter, absorption, and fluorescence, determined for TRICHODESMIUM, could be used to distinguish moderate to high concentrations (> 1 milligram chl per cubic meter) of TRICHODESMIUM from other phytoplankton. Surface scum blooms of TRICHODESMIUM have high reflectance in the near infrared. Satellite algorithms often use water leaving radiance around 750 nm for cloud detection and so flags have to be established in these algorithms to distinguish the relatively high albedo due to TRICHODESMIUM blooms from that due to clouds.

This study developed an algorithm based on the remote-sensing reflectance model that was successful in identifying TRICHODESMIUM blooms in CZCS imagery. The remote-sensing reflectance model was also used to develop an "Albedo Vegetation Index" similar to the Normalized Difference Vegetation Index. This used the visible and infrared channels of the AVHRR to map surface blooms of TRICHODESMIUM in the Arabian Sea.

Aluminum Speciation in Natural Waters Using High Performance Liquid Chromatography with Aluminum Specific Detection

Sutheimer, Susan H. 1995
Kent State University (USA), 267 pp.

The problem of metal speciation analysis as a tool to differentiate toxicity and mobility of metal ions in natural waters has long been an illusive one. The use of operationally defined methods and mathematical models has resulted in substantial progress in understanding systems containing metal ions, but the accuracy of the resultant determinations is problematic. In response to this difficulty a high performance liquid chromatographic (HPLC) method was developed to more accurately examine the concentrations of complexed and free aluminum (AL) species at the low micromolar concentrations characteristic of natural waters. Subsequently the method was used to examine the equilibrium binding of several aluminum complexes and to investigate aluminum binding to a fulvic acid and to naturally occurring dissolved organic materials in lake waters.

Al (III) was chosen as it is toxic to a variety of aquatic organisms in acid-impacted ecosystems but forms nontoxic complexes with dissolved naturally occurring materials. Initially a flow injection analysis (FIA) technique was developed which quantitatively determined monomeric forms of aluminum. The method had a detection limit of 3.7 nanoM with a linear range to 37 microM. The subsequent HPLC method used a cation exchange column and gradient flow to determine the concentration of a variety of aluminum species including Al (III) with a detection limit of 7 nM. In both methods aluminum was detected using a post column lumogallion reaction. Concentrations of aluminum citrate and aluminum fluoride complexes at equilibrium with free aluminum agreed very favorably with concentrations determined by equilibrium calculations. No dissociation of complexes was apparent. Although previously undetected by HPLC, several aluminum acetate complexes and an aluminum silicate complex were also analyzed. Formation constants for these were determined and compared to literature results.

The applicability of the HPLC method to the determination of limnologically relevant samples was demonstrated by analyzing equilibrium solutions of aluminum with Suwannee River Fulvic Acid (SRFA) and samples from acid impacted Adirondack lakes. SRFA showed significant pH-dependent binding to aluminum at pH 4.0, 5.5, 7.0 and 8.2. Although slightly less binding occurred at the higher pH values, SRFA complexes at and above pH 5 were significantly more concentrated than anticipated. By modeling the binding of SRFA to aluminum, concentrations of complexed aluminum could be estimated in acid lake waters based on pH, organic carbon content and free Al (III). Comparison of predicted values to observed lake water and literature values showed good agreement.

Although aluminum is a toxic in low pH waters, an important implication of this research was not directly related to the use of aluminum as the metal ion of choice. Other metal ions occur in freshwaters via mining and indiscriminate polluting. Many of these also exist in toxic (free) and nontoxic (complexed) forms. The successful determination of aluminum species directly by HPLC leads one to believe that the kinetic lability of some metal complexes may be less than previously postulated.

Biostabilization of Estuarine Subtidal Sediments

Sutherland, Terri-Ann F. 1996
Dalhousie University (Canada), 184 pp.

Laboratory and field studies were carried out to determine the effect of biofilms on sediment erodibility. The effect of growth and carbohydrate production of the diatom, NITZSCHIA CURVILINEATA, on sediment erodibility was explored in the laboratory. Sediment chlorophyll and bulk carbohydrate concentrations were negatively correlated with erosion rate. An increase in bulk carbohydrate content was observed at the end of exponential phase of growth. An increase in eroded aggregate size was observed with age of biofilm microfabric through carbohydrate production.

An in situ flume (Sea Carousel) was deployed at stations along a transect in Upper South Cove, Nova Scotia, and in Manitounuk Sound, Quebec, to examine the relationship between the biofilm components and sediment erodibility. In Upper South Cove, erosion thresholds and rates correlated with sediment chlorophyll and colloidal carbohydrate content. Erosion rate may be a more important index of sediment erodibility than erosion threshold, since erosion rates varied by a factor of 7, while erosion thresholds varied by a factor of 2. In Manitounuk Sound, the physical sediment properties were more sensitive indicators of sediment erodibility than the biological properties.

Microbial Activity on Wood in Streams: Exploring Abiotic and Biotic Factors Affecting the Structure and Function of Wood Biofilms

Tank, Jennifer L. 1996
Virginia Polytechnic Institute and
State University at Blacksburg (USA), 175 pp.

Research conducted in New Zealand compared the composition of the biofilm colonizing wood to that colonizing rocks and leaves in streams. Additionally, wood biofilms were compared in naturally acidic and circumneutral streams to determine the effect of stream water pH on biofilm development. Similar biofilms developed on wood veneer, natural twigs, and beech leaves, but fungi did not colonize stones where diatoms were the predominant colonizer. Comparing wood incubated on the stream bed surface to wood buried beneath the stream bed, fungal hyphae dominated the biofilm but actinomycetes and bacteria were also present. An assay of microbial activity (14C glucose uptake) indicated that surface biofilms were more active than biofilms on buried wood. There was no relationship between 14C glucose uptake and stream pH indicating that acidity did not affect wood biofilm activity in these streams.

The processes governing wood biofilms in the presence and absence of leaf litter in 2 small mountain streams at Coweeta Hydrologic Laboratory in the southern Appalachians of the United States were also examined. Microbial respiration, fungal biomass, extracellular enzyme activity, and the effect of nutrient addition were used as descriptors of wood biofilms. Exclusion of leaf litter from a headwater stream enhanced extracellular enzyme activity, and fungal biomass was 7 times higher than that in the reference stream. Relative activities of selected extracellular enzyme activities suggested that the biofilm in the reference stream was nutrient-limited. Nutrient-releasing substrates placed beneath wood veneers indicated co-limitation of nitrogen and phosphorus on biofilms in the reference stream,and nutrient limitation may have been responsible for low microbial respiration, fungal biomass, and extracellular enzyme activity on wood in the reference stream. Our results indicate that competition for nutrients by microbial biofilms may play a regulatory role in detrital processing in these streams.

Laboratory feeding studies using TALLAPERLA sp., a common macroinvertebrate shredder, were conducted to explore the suitability of wood biofilms as a food resource for shredders. There were no differences in TALLAPERLA growth rates on wood and leaves, and TALLAPERLA grew equally well on wood incubated for 1 or 2 months. TALLAPERLA nymphs were not food-limited and fungal production was able to compensate for invertebrate grazing. In the absence of leaf litter, stream shredders such as TALLAPERLA can survive and grow on the microbial biofilm on wood.

Limnology of a Man-Made Reservoir on the Western Ghats, Southern Kerala

Thomas, Sabu. 1996
University of Kerala (India), 284 pp.

In Kerala, there are 30 man-made reservoirs in addition to the 44 rivers, five major fresh water lakes and countless number of garden tanks as fresh water resources. Only very little information is available regarding the limnology of these reservoirs. Hence this study.

Peppara Reservoir (latitude 8 degrees 7' and 8 deg 53' North, longitude 76 deg 40' and 77 deg 17' East) constructed across the Karaman River in the Thiruvanathapuram District, Kerala, India was selected for the study. Four stations were selected in the reservoir for regular monthly collections of water, plankton, benthos, and sediment for a period of one year from February, 1991 to January, 1992. Samples were analysed following standard methods (Golterman et al., 1978; Jhingran et al., 1988 and Holme and Mc Intyre, 1971). Statistical analysis were done following Snedecor and Cochran (1967).

The existing literature on limnology of several Indian and foreign reservoirs has been reviewed by covering 350 references. Since the ecosystem processes in reservoirs exhibit wide variations depending on meteorological, morphometry, and hydro-edaphic features of the impoundments, an effort has been made to gauge the influence of these abiotic variables on the production dynamics of the Peppara Reservoir.

Data on various water quality parameters, primary productivity and nutrient status are presented and discussed in detail. An attempt has also been made pertaining to the ecology, spatio-temporal distribution and systematics of biotic compartments-phytoplankton, zooplankton, and benthos, to the extent possible. The correlations between plankton, benthos, and different hydrographical parameters have been examined and discussed. The various management strategies for the development of reservoir fisheries in the state have been discussed in detail. Present scenario of the reservoir fisheries in the state has been highlighted and the factors responsible for the slow rate of development were discussed.

The Influence of the Microbial Food Web on Trace Metal Cycling in Lakes: An Emphasis on the Pelagic Zone of Lake Erie

Twiss, Michael R. 1996
University of Quebec (Canada), 131 pp.

The low concentrations of dissolved trace metals observed in the surface waters of the lower Laurentian Great Lakes of North America during summer months are generally attributed to the sedimentary loss of biogenic particles from the epilimnion, in accordance with established scavenging models based solely upon the sorptive loss of solutes to particle surfaces. The majority of particles in the pelagic systems of these lakes are biotic. Among the most productive are the autotrophic picoplankton and bacteria (0.2-2 microns) that have a high potential to scavenge trace metals. The ecological fate of picoplankton in the microbial food web is predominately consumption by microzooplankton (mixotrophic and heterotrophic protozoans, 2-200 microns).

The hypothesis that microzooplankton can regenerate significant amounts of trace metal into the dissolved phase through the incomplete assimilation of trace metals from their prey was tested in the laboratory and in the field. Radionuclides were used to follow the fate of trace metals ingested in a particulate form by microzooplankton. Rapid regeneration of trace metals from the particulate to the dissolved phase (<0.2 microns) was observed in a laboratory model of a simple Great Lakes microbial food chain, composed of a mixotrophic nanoflagellate (OCHROMONAS) grazing Cs-137, Cd-109, Zn-65, and Gd-153-radiolabeled picocyanobacteria (SYNECHOCOCCUS). Most of the trace metal consumed as prey was regenerated by OCHROMONAS; regenerated Gd-153, Zn-65, and Cd-109 had reduced bioavailability, in comparison with inorganic forms of the same elements. Trace metal regeneration was also observed in the natural plankton community sampled from the pelagic region of Lake Erie during thermal stratification. Cd-109 and Zn-65-radiolabeled SYNECHOCOCCUS was used to label the picoplankton community in lake water and to trace the effect of natural grazing activity on the size fractionation of these metals. Trophic transfer and recycling of regenerated trace metal by microbial food-web organisms was observed. Most regenerated trace metal radionuclides remained in the dissolved phase.

A model of trace metal fate in surface waters under steady-state conditions was based on observed trace metal scavenging and biological characteristics of the microbial food web. Trace metal residence times of Cs (514 d), Cd (29 d), Zn (32 d), and Gd (66 d) predicted by the model were 46%, 62%, 58%, and 84% greater, respectively, than residence times predicted if microzooplankton grazing activity was eliminated from the model simulations.

These results are the first unequivocal demonstration of trace metal regeneration by microzooplankton grazing activity, and illustrate the importance of the microbial food web in determining the geochemical fates of particle-reactive trace metals in the pelagic surface waters of large lakes during thermal stratification.

Behavioural Energetics of the Parrotfish *Sparisoma viride*: Flexibility in a Coral Reef Setting

van Rooij, Jules M. 1996
University of Groningen (The Netherlands), 245 pp.

The stoplight parrotfish (SPARISOMA VIRIDE) is a large and common herbivore on many Caribbean coral reefs. Until recently, hardly any quantitative data were available on the uptake and transfer of nutrients and energy by scarids, despite their important role in these "oases of diversity." This project was set up to construct a detailed field budget for a population of S.VIRIDE at Bonaire, the Netherlands Antilles. The main question addressed in this trophodynamic context is how efficiently it converts its food into growth and gamete production.

Over 1600 hours of underwater observation were spent studying the behaviour and energetics of individually recognized fish and the structure and density of the population. Some new methods and equipment were developed for direct estimation of the major energy expenditures, viz. stereo photography to measure growth, a hoop net for field collection of eggs, an underwater event recorder for simultaneous records of behaviour, bite rates, fin beats, and ventilation frequency, and establishment of the relationship between ventilation frequency and oxygen uptake (allowing field estimates of metabolic rates) and between fin beat frequency and swimming speed (as a measure of swimming activity). This detailed approach resulted not only in an accurate estimate of the total amount of energy, carbon, and nitrogen processed by the population, but also revealed a high degree of intrapopulation variability that could be related to behavioural ecology and life history theory. In this context, the adaptive significance of territorial behaviour and of early sex change have been investigated.

Comparison of total energy expenditure with independent estimates of energy intake and absorption obtained in a parallel study, shows that S.VIRIDE can live on a strictly algal diet. In fact, total production as a fraction of intake yielded quite a low energy conversion efficiency (1.8%), whereas nitrogen was processed more efficiently (18%). However, expressed as fraction of the assimilated energy (9%) or nitrogen (40%), food conversion compares well with values reported for carnivorous fish. It is concluded that an important fraction of the excavated algal material is not used by S.VIRIDE itself, but transferred to micrograzers and/or the microbial web.

A major distinction could be made between territorial males and males sharing common home ranges. The latter showed much higher growth rates, despite a relatively poor food supply. This could be explained by the high activity of territorial males related to territory defence, resulting in elevated metabolic rates. In return, they had guaranteed access to a number of harem females and attained much higher spawning frequencies. Calculations of the expected lifetime reproductive output (based on size-dependent mortality and spawning rates) indicated that individual differences in the timing of sex change and in the lifetime pattern of growth and reproduction are adaptive. The capacity to flexibly adapt its behaviour and physiology in response to an unpredictable environment, may well explain the success of S. VIRIDE.

Recent Benthic Foraminiferida of Two Salt Marshes on St. Catherines Island, Georgia: Paleological Implications

Venn, Cynthia. 1996
University of Pittsburgh (USA), 126 pp.

Delineation of modern foraminiferal populations of two SPARTINA ALTERNIFLORA marshes on St. Catherines Island will aid in future interpretation of relict marsh muds. Foraminifera and meiofauna in Engineer Point Marsh (EP) and Hoke's Landing Marsh (HL), two SPARTINA marshes with distinct hydraulic and sedimentologic characteristics, were investigated (1) to determine whether foraminifera comprise a notable proportion of the meiofaunal size fraction, and (2) to characterize foraminiferal populations in the low marshes. Surface cores of 20 cubic centimeter volume were stained and preserved; all representatives of the stained meiofaunal fraction and both the stained and unstained foraminiferal fraction were identified and tallied. Foraminiferal populations form a substantial fraction of the meiofaunal size fraction. Ecological studies of meiofauna should therefore include foraminifera.

AMMONIA BECCARII and AMMOTIUM SALSUM dominate the foraminifera assemblages in both marshes, but populations of the two marshes are best distinguished using the rarer species. Samples contain far more species (145 and 107 in EP and HL, respectively) than have been enumerated in previous marsh studies; the majority of species in each marsh represent less than 2% of the sample assemblage. The standard counts of 300 specimens utilized in most foraminiferal studies may result in notable underestimation of species diversity. Live to total ratios indicate different taphonomic processes dominating in each marsh, with enrichment of agglutinated taxa in the total assemblage. The higher energy hydraulic regime of EP marsh favors postmortem transport of empty calcareous tests and retention of the coarsely agglutinated AMMOTIUM/ AMMOBACULITES group. Lower hydraulic regime of HL marsh results in dissolution of calcareous tests and accumulation of the finer agglutinated taxa. Comparison of the modern to a relict marsh mud fauna described by Goldstein (1988) indicates additional taphonomic processes may be occurring.

Foraminiferal assemblages are similar to those found on Sapelo Island, Georgia, and are closer to Gulf of Mexico faunas than to faunas of New England and Nova Scotia marshes. It is important to recognise these differences in initial species composition if we wish to interpret the paleoenvironment of relict assemblages.

Recent and Late-Holocene Paleolimnology of Lakes Naivasha and Sonachi, Kenya

Verschuren, Dirk. 1996
University of Minnesota (USA), 320 pp.

Lakes Naivasha and Sonachi (Eastern Rift, Kenya) together form a complex of four limnologically and sedimentologically distinct, but hydrologically interconnected shallow lake basins: the main basin of Lake Naivasha, Crescent Island Crater, Lake Oloidien, and Lake Sonachi. This system therefore constitutes a natural laboratory to study how basin hydrology, morphometry, mixing regime, and sedimentation patterns affect the formation and preservation of climate-proxy signatures in the lake-sediment record. This study calibrates climate-proxy signatures in 210 Pb-dated sediment profiles from each basin against documentary evidence of climatically driven lake-level and salinity change over the past century. The results demonstrate that the continuity and temporal resolution of a climate-proxy record strongly depend on the persistence and quality of the local depositional environment, as determined by the physical and chemical limnology of the particular lake basin. Further it is found that at all time scales gradual environmental change will be recorded as an apparent steplike event when change in the selected climate proxy is controlled by limnological or sedimentological thresholds. Calibration of the recent sediment record in all four basins is then used to interpret the lithostratigraphy of an 8.20-meter long sediment profile from Crescent Island Crater, representing the last 1500 years of climatic history in equatorial East Africa.

Ecological aspects of the dissertation focus on the potential of fossil assemblages of aquatic invertebrates to resolve past water-level fluctuations in African lakes on a time scale of decades. Analysis of the stratigraphic distribution of fossil Chironomidae, Ostracoda, and Cladocera in recent sediments of lakes Oloidien and Sonachi form the basis for an investigation of the mechanisms regulating aquatic-invertebrate communities of shallow fluctuating lakes in tropical Africa. The results indicate that in addition to salinity, also mixing regime and availability of preferred substrate are important ecological determinants controlling the immigration, expansion, and local extinction of individual invertebrate species. It is argued that analysis of fossil invertebrate assemblages can be a valuable complement to quantitative methods of paleosalinity inference because of its ability to reconstruct lake-level change independently from salinity change. Due to non-linearity in the relationship between the water level and salinity of fluctuating lakes at short time scales, this ability gains importance together with the need for increased temporal resolution and precision in the reconstruction of past climate.

Relative Abundance and Species Diversity of Autotrophic Ammonia-Oxidizing Bacteria in Aquatic Systems

Voytek, Mary A. 1996
University of California at Santa Cruz (USA), 241 pp.

Nitrification, the two-step oxidation of NH4+ through NO2- to NO3- is important as an oxygen sink, a source of substrates for denitrification (which leads to loss of fixed nitrogen from the system), in the production of N2O (a greenhouse gas implicated in ozone depletion), and in the supply of NO3- which fuels surface primary productivity. Nitrification is exclusively a bacterial process and is carried out by two genetically similar guilds of chemoautotrophic bacteria (ammonia and nitrite oxidizers). This dissertation describes research on the ammonia oxidizers which, although essential in the biogeochemical cyles of aquatic ecosystems, account for a minor proportion of the total bacterial population.

Questions regarding the role of nitrifying bacteria in natural aquatic environments remain unanswered to date partly because of the lack of simple, rapid, and sensitive detection, identification, and quantification procedures. The goal of this dissertation was to develop techniques that would allow the detection, enumeration, and evaluation of species diversity of ammonia oxidizers in natural aquatic systems, and in turn, to begin investigating the ecology and environmental importance of natural populations of nitrifying bacteria.

Two sets of sensitive and specific PCR primers for the detection of both subclasses of ammonia oxidizers were developed and tested on DNA samples collected from two disparate aquatic environments, an Antarctic lake and the Southern California Bight. Ammonia oxidizers were detected at both locations. These primers were then used to examine the relative abundance and depth distribution of ammonia oxidizers in six perennially ice-covered lakes in the McMurdo Dry Valleys, Antarctica. The observed distribution of nitrifiers in all lakes could be interpreted in terms of patterns predicted from environmental factors known to control nitrifying activity.

To estimate the abundance of nitrifiers in natural samples, three quantitative techniques were compared. Although the overall distribution patterns observed were similar, the subset of the total nitrifying community detected varied with each technique, since each of the techniques relies on a different macromolecular component of a bacterial cell, which responds differently to stages in the cell cycle and to environmental factors. Finally, two PCR-based techniques, RFLP analysis and direct sequencing, were used to examine the genetic diversity of cultured marine beta ammonia-oxidizers and nitrifier 16S rRNA genes retrieved from natural seawater. The marine isolates in culture were nearly identical to the type strain NITOSOMONAS MARINA, while the genes retrieved from seawater did not resemble any of the cultured strains. The results suggest that although Nitrosomonads may be readily isolated from marine systems, they may not be the most dominant nitrifying species present in a community and therefore, not the most ecologically important.

A Study on the Characteristics, Leaching and Toxicity of Fly Ash from I.P. Thermal Power Station, Delhi and the Impact Assessment of Its Disposal on the Limnology of River Yamuna

Walia, Archana. 1995
University of Delhi (India), 169 pp.

During the last few decades, demand for electricity has increased enormously. Due to the inherent problems associated with nuclear and hydroelectric power generation, thermal power plants with coal as a source of energy are gaining importance even in non-coal producing regions.

Fly ash, a by-product of coal combustion, is prevalently disposed by wet-sluicing from electrostatic precipitators to on- or off-site ponds. This system disposes of ash as a slurry which is pumped into a natural or constructed basin where ash settles and supernatant is drained into a water body such as a river or a lake. Many elements present in coal get preferentially incorporated in and around fly ash particles during combustion. Most of these elements are soluble in water and thus become available to the biological systems.

The impact of wet disposal of the by-products from a 200 MW capacity I.P. thermal power station on the limnology of the river Yamuna, Delhi was studied. The power station uses about 4000 tons of bituminous grade-F coal which has about 40% solid residue content. A two-year field survey of the seasonal variation in the limnology of the impacted and non-impacted segments of the river and the ash ponds reveal that conductivity, TDS, DO, hardness, sulphates, nitrite and elements viz., Al, Sb, Bi, Cd, Cr, Co, Li, Mn, Mo, K, Si, and Zn increased significantly in the impacted waters. Also the phyto- and zooplankton density and diversity was reduced and the composition of various groups was drastically changed at the impacted site.

Laboratory studies were carried out on the physico-chemical characterization of fly ash, solubility behaviour of components associated with fly ash,ß and the effect of fly ash leachates on representative phyto- and zooplanktonic organisms in order to assess the potential impact of fly ash effluents on river water quality. Fly ash leachates adversely affected the growth parameters of plankton with the degree of toxicity related to the concentration of the leachate, the duration of exposure, and the test organism.

This study clearly suggests that fly ash effluent is a potential environmental hazard which can have far reaching adverse effects on the receiving water.

Acclimation and Adaptation to Pollutants: Effects on Metal Trophic Transfer

Wallace, William G. 1996
State University of New York at Stony Brook (USA), 153 pp.

The acclimation and adaptation to cadmium (Cd) by the aquatic oligochaete LIMNODRILUS HOFFMEISTERI was investigated for its role in controlling bioavailability and toxicity of Cd to the predatory grass shrimp PALAEMONETES PUGIO. Acclimation to Cd and its effect on Cd trophic transfer were investigated by varying the concentration and duration to which nonresistant oligochaetes were exposed to Cd and determining the relationship between oligochaete subcellular Cd distributions and Cd bioavailability to shrimp. The consequences of adaptation to Cd on Cd trophic transfer was investigated by collecting oligochaetes along a Cd-contamination gradient in a metal-polluted (Cd, Ni and Co) cove on the Hudson River (Foundry Cove) and determining differences in Cd resistance, subcellular Cd distributions, and Cd bioavailability to shrimp. The toxicity of Cd sequestered within oligochaetes was studied by investigating alterations in prey capture and induction of Cd-binding proteins in shrimp fed Cd-contaminated oligochaetes.

Acclimation to Cd resulted in an increase in the proportion of Cd bound to the cytosol of oligochaetes (possibly due to the production of metallothionein-like proteins) and in the proportion of Cd biologically available to shrimp; Cd bound to cytosol was completely absorbed by shrimp. Oligochaetes chronically exposed to Cd evolved Cd resistance and produced Cd-rich granules. Cd sequestered in granules was biologically unavailable due to the insolubility of these concretions.

Shrimp fed Cd-contaminated prey items (LIMNODRILUS HOFFMEISTERI OR ARTEMIA SALINA) exhibited significant and obvious reductions in their ability to effectively capture live prey (A. SALINA). Just as with oligochaetes exposed to Cd via solution, the percentage of Cd bound in the cytosol of shrimp increased with increased Cd exposure; induction of Cd-binding proteins (metallothioneins) was directly responsible for this increase in cytosol bound Cd. Additionally, prey capture success was inversely related to (1) the percentage and amount of Cd bound in the cytosol of shrimp, (2) shrimp Cd body burdens, and (3) the amount of Cd bound to the high molecular weight protein fraction of shrimp cytosol (i.e., Cd not detoxified via metallothioneins).

This study has integrated physiological induction of metal detoxification systems, development of metal resistance, and effects on metal trophic transfer and toxicity to predators. This scheme represents the development of a physiological approach to understanding the impacts of metals on aquatic environments, and, together with previous work, describes a model linking molecular aspects of metal resistance in prey to direct consequences to predators, and by extension to the ecosystem as a whole. This model extends beyond Cd, oligochaetes and grass shrimp to include other predator/prey relationships in which other toxic metals (i.e., Cu, Zn, Co, Ni, Cr, Ag and Hg) are sequestered and detoxified by similar mechanisms.

Macrozoobenthos Communities on Stony Beach of Lake Baikal

Weinberg, Irina V. 1995
Irkutsk State University (Russia), 130 pp.

The author's sampling on western coast Southern Baikal in 16 km northeast from the source of the Angara River was a material for work. A quantitative survey was done monthly during a period from April 1989 to August 1990. Benthic samples selected on the water edge, 1 and 2 meters (m) higher of it towards the land and through each meter lower of the water edge during 20 m. Abiotic factors affecting zoobenthos have been recorded. The periods, differing on character changes of a beach, have been allocated. The minimum index of benthos are marked during the maximum hydrodynamic influence, the maximum index - during the minimum hydrodynamic activity - in the subice period. 30 species of benthic animals have been found at the beach zone (water edge and underwater edge zone). They belong to Turbellaria, Hirudinea, Oligochaeta, Polychaeta, Bathynellacea, Amphipoda, Isopoda, Plecoptera, Trichoptera, Chironomidae, Mollusca, Collembola, Diptera larvae, Coleoptera larvae, and Acarina. All animals found in a beach fall into three groups: occasional species, migrating species, and obligatory beach dwellers. Obligatory beach dwellers consist of two species complexes: amphybionts and hydrobionts. This is peculiar for marine supralittoral. Five macrozoobethic communities were found: 3 communities with dominant amphipods, 2 with dominant oligochaets. Predominance of this or that zoobenthic species is determined by the size of substratum pores. Communities are formed during periods of weak hydrodynamic stress (May - August) in a beach zone with appropriate grounds. While increasing of a hydrodynamic effect on the beaches (September - December), the communities migrate to the zones of weak hydrodynamic stress, and they are missing at a water edge. Biology of endemic amphipod EULIMNOGAMMARUS CYANEUS has been investigated. This species is an attractive model for micro-evolutionary studies since it inhabits a very narrow zone a few meters wide, and 2 000 kilometers long.

The Significance of Sediment Resuspension in Lakes

Weyhenmeyer, Gesa A. 1996
Uppsala University (Sweden), 162 pp.

To better understand the geochemical, biological, and toxicological impacts of sediment resuspension on lake ecosystems, this study focuses on questions where, why, when, how much, and what kind of sediment is resuspended and how the resuspended material is distributed in the water column. With data from a Sea Tech transmissometer and data from sediment traps it is shown that internal seiche activities are likely to be responsible for sediment resuspension in deeper areas of stratified lakes. Sediment traps were also used to develop a simple method which allows to quantify the proportion of resuspended settling particulate matter in lakes, and to distinguish organic resuspended settling particulate matter from newly produced planktonic settling particulate matter. In all 9 studied lakes, the dominant source of settling particulate matter was sediment resuspension, and in 4 of the 9 lakes sediment resuspension was even the dominant source of organic settling particulate matter.

Since settling particulate matter in the studied lakes usually consisted to a major part of resuspended particulate matter, even during phytoplankton blooms, the vertical distribution of resuspended and total settling particulate matter in the water column was similar during all seasons. Resuspended settling particulate matter was accumulated in hypolimnetic traps by a factor of up to 45 during the period of stratification (arithmetic mean: 9.5; median: 6.0). However, as soon as the period of stratification was over, resuspended settling particulate matter was almost evenly distributed in the water column. In contrast to this sedimentation pattern, the flux of newly produced planktonic settling particulate matter reaching the hypolimnion was not affected by stratification.

With the above knowledge and from a literature review, relationships between sediment resuspension and lake water pollution were compiled and discussed in connection with processes such as sorption and desorption, biouptake, and pollution dynamics - chronic versus pulse inputs.

Finally, a model was developed which can be used to determine (1) the minimum, mean and maximum flux of settling particulate matter in lakes, (2) daily variations in the flux, origin, and distribution of settling particulate matter both during stratification and mixing of the water column, (3) the boundary depth between accumulation and erosion/transportation bottoms, (4) the yearly sediment accumulation rates at different water depths, and (5) sediment focusing.

A Paleolimnological Assessment of Late Quaternary Environmental Change on Southwestern Cumberland Peninsula, Baffin Island, Northwest Territories, Canada

Wolfe, Alexander P. 1994
Queen's University, Canada, 161 pp.

A paleolimnological approach is used to evaluate the Late Quaternary paleoenvironments of southwestern Cumberland Peninsula, Baffin Island. Lakes selected for study are situated on a weathered upland (66 degrees 16' North, 65 deg 45' West; 545-848 meters above sea level) that escaped Late Wisconsinan (Foxe) glacial modification, thereby permitting the retrieval of unusually ancient sedimentary sequences. Poorly buffered limnological conditions, punctuated by intense pulses of acidic nival meltwater, are conducive to floras of primarily acidophilous diatoms.

To test the assumption that a single core suffices to adequately depict a lake's ecological evolution, a network of samples was taken from Ukalik Lake, the lowest of the investigated lakes. Processes of diatom transport and deposition are evaluated by analyses of periphytic, planktonic, and epipelic habitats. Surface sediments (0-1 centimeter) contain taxa that are alternately highly equitable and variable between sites. AULACOSEIRA and ACHNANTHES spp. have remarkably even spatial distributions, indicating thorough mixing of their valves in the water column prior to deposition. On the other hand, frequencies of several benthic (epipelic) taxa (e.g. PINNULARIA BICEPS, EUNOTIA spp.) vary up to 30% between stations, in patterns that reflect minimal transport prior to burial. This variability is somewhat smoothed in cores because samples integrate longer periods of deposition. Ordination by Correspondence Analysis (CA) is used to compare the cores, test the coherence of their respective paleoecological records, and verify that central cores indeed contain the most useful paleoecological information.

Diatom analyses and 14C dates from Amarok and Tulugak Lakes, the longest-continuous records of lacustrine sedimentation from the eastern Canadian Arctic to date, indicate four major phases of lake development during the past 20,000 years. Planktonic AULACOSEIRA spp. (principally A. DISTANS and A. PERGLABRA) are dominant between 20 and 12.8 thousand years before present and during the last 5 thousand years. The earliest organic sediments are characterized by alkaliphilous FRAGILARIA spp., which are progressively replaced, in sediments of early to mid-Holocene age, by diverse assemblages of benthic acidophils (e.g. FRUSTULIA, BRACHYSIRA and EUNOTIA spp.). Stratigraphic changes in diatom life-form and pH tolerances are related to both regional paleoclimatic conditions and local edaphic factors. The occurrences of planktonic floras during the cold Late Foxe and Neoglacial periods suggest that, even at these times, the lakes became ice-free during summer. The interplay of enhanced runoff as a mechanism of ice disintegration and increased Si supply by erosional processes enabled AULACOSEIRA to flourish at these times. Early and mid-Holocene limnological regimes were more strongly controlled by authigenic factors, including the biogeochemical processes responsible for the production and subsequent breakdown of within-lake alkalinity production. Collectively, these results highlight the extreme chemical and ecological sensitivities of non-glacial arctic lakes, thereby validating the utility of their sedimentary records in the study of environmental change.

Investigations on the Importance of Phytoplankton as a Component of Suspended Matter in the Elbe Estuary

Wolfstein, Kirsten. 1996
University of Hamburg (Germany), 164 pp.

The composition and settling behaviour of suspended particulate matter (SPM) from the limnic to the polyhaline zone of the Elbe Estuary of northern Germany was studied from 1992 to 1994 to receive substantial data, important for management proposals for sediment dredging in the harbour and the river Elbe. Special attention was given to organic content, phytoplankton pigments, and species composition in suspended matter of different settling velocities. SPM was separated into three fractions of different settling velocities using an Owen tube.

The main part of SPM settled slower than 0.3 millimeters per second (mm/s). This type of SPM was distributed nearly homogeneously over the water column. SPM having a settling velocity higher than 1.9 mm/s was mainly present near the bottom. Downstream of Hamburg harbour phytoplankton contributed only a very small part to the total content of SPM. Chlorophyll-A, taken as a parameter of algal biomass, made up only 0.3% of the total suspended matter. Contrary to the total organic content which was always highest in the slow settling fraction (about 80-90%), up to 30% of chlorophyll-A associated with SPM was found in the mean and fast-settling fraction. Degradation products of chlorophyll-A associated with SPM even had more often highest values in both faster-settling fractions than native chlorophyll-A. Bacillariophyceae and Dinophyceae were represented preferentially in the fast-settling fraction, whereas the number of Chlorophyceae and Cyanobacteria was higher in the slow-settling fraction. The most important abiotic factors correlated with the amount of chlorophyll-A of total SPM contents were water temperature and light or turbidity, respectively. Phytoplankton species composition was mainly influenced by salinity. Positive correlations between the amount of algal pigments and exoenzymatic activity of heterotrophic bacteria were observed.

The Microbial Fate of Carbon in High-Latitude Seas: Impact of the Microbial Loop on Oceanic Uptake of Carbon Dioxide

Yager, Patricia L. 1996
University of Washington (USA), 174 pp.

This dissertation examined pelagic microbial processes in high-latitude seas, how they affect regional and global carbon cycling, and how they might respond to hypothesized changes in climate. Critical to these interests is the effect of cold temperature on bacterial activity. Also important is the extent to which marine biological processes in general impact the inorganic carbon cycle. The study area was the Northeast Water (NEW) Polynya, a seasonally-recurrent opening in the permanent ice situated over the northeastern Greenland continental shelf. This work was part of an international, multi-disciplinary research project studying carbon cycling in the coastal Arctic.

The first chapter describes a simple model which links a complex marine food web to a simplified ocean and atmosphere. This model is designed to test the sensitivity of the air-sea flux of carbon to microbial food web structure and behavior, particularly those processes which might be sensitive to warming. Preliminary results suggest that organisms can impact short term air-sea carbon flux.

The second chapter investigates the inorganic carbon inventory of the summertime NEW Polynya surface waters to establish the effect of biological processes on the air-sea pCO2 gradient. A unique one-way sink for atmospheric carbon is hypothesized for the NEW Polynya and other seasonally ice-covered seas. If this type of one-way carbon sink occurs on a global scale, it may provide a significant negative feedback to greenhouse warming.

The third and fourth chapters use a kinetic approach to examine microbial activities in the NEW Polynya as a function of temperature and dissolved organic substrate concentration, testing the so-called "Pomeroy hypothesis" that microbial activity is disproportionately reduced at low environmental temperatures owing to increased organic substrate requirements. With field experiments, responsive microbial communities of mostly psychrophilic (cold-loving) organisms were often found to exhibit high affinities to and high incorporation efficiencies on nitrogen-rich organic matter; their response to temperature was heterogeneous, however, indicating that controls on microbial behavior may not be as simple as previously believed. Together, the suite of data collected on microbial activities, cell size, and grazing pressure suggest how unique survival strategies adopted by an active population of high-latitude bacteria may contribute to, rather than detract from, an efficient biological carbon pump.

The Role of Intertidal Spawning on Egg Survival and the Measurement of Selection on the Spawning Tide Level of the Puffer *Takifugu niphobles*

Yamahira, Kazunori. 1996
Kyushu University (Japan), 60 pp.

Marine environment fluctuates physically on a variety of time scales but principally with the diurnal, tidal, and lunar or semilunar cycles. These cycles affect many aspects of the life histories of marine organisms and they often coordinate reproductive activity within species. This study disentangles combined responses to the variety of physical fluctuation and estimates their relative importance in formation of the patterns in the reproductive timing and measures quantitatively the intensity of selection pressure on the patterns.

The puffer TAKIFUGU NIPHOBLES, an intertidal spawner, spawns only during rising tidal phases of dusk on several days of spring tides. Multiple regression analyses indicated that a day's spawning time was regulated not only by the tidal but also by the diel cycle. This suggests that the fitness components of the spawning reactions to both cycles should be examined separately, and that the semilunar spawning pattern is formed by a temporal combination of both fitness components. However, the spawning days shifted from just before to just after the new or full moon, as the season progresses. The seasonal shift was considered to be the result of a seasonal trade-off between embryo survival during intertidal incubation and hatching success.

The spawning linkage with the tidal cycle makes it possible for the fish to spawn in the upper intertidal zone. Experimental manipulation of the spawning tide level indicated that selection pressure to lower the spawning tide level was relatively larger in a pebble beach than in a sandy beach. In addition, the pattern of a day's time of spawning, which is the quantitative trait determining the spawning tide level, across the spawning sites changed in a manner that is consistent with the estimated intensity of selection pressure, suggesting that there is an evolutionary response of the trait to the selection.

A phenotypic trait is formed by various biotic and abiotic factors and these sometimes function as countervailing selection agents. This study showed that to disentangle and measure each selection pressure is important for understanding phenotypic evolution. Besides, it is considered that the measurement of selection pressure by experimental manipulation of traits can be widely applied even when opportunity of selection is too small, because such manipulation emphasizes phenotypic variation within a population.

Cobalt Substitution for Zinc in Marine Phytoplankton

Yee, Donald. 1997
Massachusetts Institute of Technology (USA), 167 pp.

Cobalt is a trace metal which behaves as a nutrient in some marine phytoplankton species. Although cobalt concentrations in the open ocean are typically at least an order of magnitude less than those of zinc, in some regions of the ocean where zinc is extremely depleted, cobalt concentrations approach those of zinc.

Laboratory cultures of marine phytoplankton demonstrate that cobalt additions to culture media can alleviate zinc limitation of growth. This substitution can restore growth to near maximum rates in zinc-limited oceanic species, but is less effective in coastal phytoplankton. The effectiveness of cobalt substitution is correlated to the concentrations of zinc at which species become zinc-limited: the lower the zinc concentration necessary for growth, the more effective the cobalt substitution. Analysis of cellular metal contents show that oceanic species have relatively high cobalt to zinc ratios, and thus a lesser preference for zinc over cobalt than do coastal species.

One mechanism by which the substitution of cobalt for zinc occurs in the coastal diatom THALASSIOSIRA WEISSFLOGII is by direct metal substitution in a soluble form of the zinc enzyme carbonic anhydrase, which is used in acquiring inorganic carbon. A similar soluble carbonic anhydrase was found in an oceanic diatom as well. The function of both zinc and cobalt in carbonic anhydrase of T. WEISSFLOGII is apparent from the alleviation of carbon limitation in cultures under low partial pressures of carbon dioxide (CO2) by addition of either zinc or cobalt to the culture medium.

Assays of soluble proteins in other phytoplankton indicate that another function in which cobalt may substitute for zinc is in the enzyme superoxide dismutase. In contrast, cobalt does not appear to substitute for zinc in RNA and DNA polymerases. Despite the lack of direct substitution of cobalt for zinc in the nucleic acid fraction of zinc-limited cells, cobalt additions cause redistribution of cellular zinc from the insoluble to the soluble and nucleic acid fractions of a cell. This effect, as well as the presence of a large part of total cellular zinc in the insoluble fraction of many phytoplankton, suggest that a major role of cobalt substitution for zinc occurs in proteins found in membranes. This insoluble protein may be a form of carbonic anhydrase, as a positive response to metal addition under low CO2 is found some phytoplankton species when zinc and cobalt are added, despite assays showing no carbonic anhydrase activity in the soluble fraction of these algae. Despite the fact that cobalt substitution for zinc may occur chiefly in membrane-bound proteins, nearly half the cellular cobalt is always found in an unknown low molecular weight compound. This compound may be a phytochelatin complex which acts as an internal cobalt buffer.

The effect of zinc and cobalt in alleviating carbon limitation may be reflected in the distributions of these metals in the surface oceans: the concentration of cobalt in surface waters follows nutrient-like vertical profiles where zinc is very depleted and surface temperature is high; the decreased solubility of CO2 warm waters may require phytoplankton in these regions to produce carbonic anhydrase to enhance inorganic carbon uptake and thus utilize cobalt in the absence of sufficient zinc.

Peculiarities of Oogenesis and Reproductive Cycle in Ecologically Different Species of Baikalian Cottid Fishes (Cottidae, Abyssocottidae)

Zubina, Larisa V. 1995
Russian Academy of Sciences at St. Petersburg (Russia), 199 pp.

Oogenesis and reproductive cycles have been studied in sculpin species inhabiting four different ecological zones. COTTOCOMEPHORUS GREWINGKI inhabits coastal pelagic zone (20-300 meters), PARACOTTUS KNERI and COTTUS KESSLERI are found in coastal benthic zone (0,1-250 meters), LIMNOCOTTUS MEGALOPS is restricted to underwater steep slope (200-600 meters). In addition some data about the reproduction of 4 species of Baikalian Cottoidei: COMEPHORUS DYBOWSKII, PROCOTTUS MAJOR, ASPROCOTTUS HERZENSTEINI and ABYSSOCOTTUS KOROTNEFFI have been used.

The following general characteristics of oogenesis and reproductive cycles are common to the species studied: (1) they share the same sequence of events in the process of oogenesis; (2) older generation of oocytes develops in a concerted fashion; (3) reserve stock of oocytes is always available; (4) prolonged III stage of gonads maturity and short IV stage.

Some possible means of adaptation of these species to cold Baikalian habitats have been determined. These are: (1) the presence of basophilic zones (or circumnuclear ring) in the oocytes of previtellogenic development during the entire year, (2) stimulation of vitellogenesis of low water temperature, (3) postspawning condition of gonads corresponds to VI-III stage of a gonads maturity: older generation of reserve stock oocytes is represented by trophoplasmatic growth cells developing longer than one year, (4) formation of restricted breeding groups or reproductively isolated populations with particular season rhythms of gonads.

In the shallow water dweller COTTUS KESSLERI due to a warmer water of habitat postspawning gonads are at stage VI-II and older generation of the reserve stock oocytes is represented by previtellogenic cells and previtellogenic oocytes have basophilic zones only in winter.

Morphological sturucture of oocytes is different at P. KNERI and C. KESSLERI (both are near-shore bottom species). The oocyte morphology of P. KNERI is similar to the one of deep-water species. In C. KESSLERI it is closer to the pelagic viviparous C. DYBOWSKII.

PROGRAM PARTICIPANTS

Ahmed, Mahmoud H. M. oce
Coastal Research Institute (CRI)
15 El-Faraana St., 21514, El-Shallalaat,
Alexandria
EGYPT
Tel: 0203-5500989
Fax: 0203-5457611
igsr-alx@frcu.eun.eg
marine pollution; coastal erosion;
environmental impact assessment

Aldridge, Frederick J. lim
Fisheries & Aquatic Sciences Department
University of Florida
7922 N.W. 71 Street
Gainesville, FL 32653
USA
Tel: 352-392-9617 x 235
Fax: 352-846-1088
iffsh13@nervm.nerdc.ufl.edu
phytoplankton; limiting factors; dynamics

Avery, G. Brooks Jr. lim
924 Talinga Lane
Wilmington, NC 28412
USA
Tel: 910-962-7388
averyg@uncwil.edu
carbon cycling; organic matter
remineralization;
stable isotope geochemistry

Basu, Ben K. lim
Department of Biology
University of Ottawa
30 Marie-Curie
Ottawa, ONT K1N 6N5
CANADA
Tel: 613-562-5718
Fax: 613-562-5486
bbasu@oreo.uottawa.ca
rivers; plankton; food webs

Berman-Frank, Ilana lim
Kinneret Limnological Laboratory
Hebrew University
POB 345
Tiberias 14102
ISRAEL
Tel: 972-6-6721444
Fax: 972-6-724627
irfrank@vms.huji.ac.il
phytoplankton; ecology; CO2 limitation

Bezrukova, Elena lim
Laboratory of Paleolimnology
Limnological Institute
Russian Academy of Sciences
Ulan-Batorskaya St., 3
Irkutsk 664033
RUSSIA
Tel: 3952-466926
Fax: 095-4202106
root@lin.irkutsk.su
Lake Baikal; palynology; paleoclimate

Boetius, Antje oce
Biological Oceanography Department
Baltic Sea Research Institute
Seestr. 15
Rostock-Warnemuende 18119
GERMANY
Tel: 49-381-5197-257
Fax: 49-381-5197-440
antje.boetius@io-warnemuende.de
microbial ecology; deep-sea biology;
benthic biology

Brewer, Matthew C. lim
Physiological Ecology Department
Max Planck Institute for Limnology
Postfach 165
Ploen D24306
GERMANY
Tel: 49 4522-763291
Fax: 49 4522-763310
mbrewer@mpil-ploen.mpg.de
zooplankton; behavior; predator-prey

PROGRAM PARTICIPANTS

Caceres, Carla E. lim
Center for Aquatic Ecology
Illinois Natural History Survey
607 E. Peabody Drive
Champaign, IL 61820
USA
Tel: 217-244-2139
Fax: 217-333-6294
caceres@mail.inhs.uiuc.edu
Daphnia; diapause; lakes

Callisto, Marcos lim
Lab. Ecologia de Bentos/Limnologia
Universidade Federal de Minas Gerais
CP. 486, CEP.30.161-970
Belo Horizonte, MG
BRAZIL
Tel: 55-31-448-1358
Fax: 55-31-441-5481
callisto@mono.icb.ufmg.br
benthic macroinvertebrates; biomonitoring; chironomidae

Chai, Fei oce
School of Marine Sciences
University of Maine
5741 Libby Hall
Orono, ME 04469-5741
USA
Tel: 207-581-4317
Fax: 207-581-4388
fchai@saturn.caps.maine.edu
ecosystem modeling; El Nino; carbon cycle

Cohen, Andrew N. oce
San Francisco Estuary Institute
1325 South 46th Street
Richmond, CA 94804
USA
Tel: 510 -231-9423
Fax: 510-231-9414
acohen@sfei.org
biological invasions; estuarine ecology; marine biodiversity

Cottingham, Kathryn L. lim
National Center for Ecological Analysis and Synthesis
University of California at Santa Barbara
735 State St, Suite 300
Santa Barbara, CA 93101-3351
USA
Tel: 805-892-2522
Fax: 805-892-2510
cottingh@nceas.ucsb.edu
nutrient-food web interactions; ecosystem stability;
ecological indicators

D'Sa, Eurico J. oce
NOAA/NESDIS - E/RA3
5200 Auth Road
Camp Springs, MD 20746
USA
Tel: 301-763-8102, ext. 50
Fax: 301-763-8020
edsa@nesdis.noaa.gov
ccean optics; instrumentation; continental shelf

Daly, Kendra L. oce
Division of Ocean Sciences
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230
USA
Tel: 703-306-1587
Fax: 703-306-0390
kdaly@nsf.gov
zooplankton ecology; biogeochemical cycles; polar oceanography

Ferreri, C. Paola lim
School of Forest Resources
Pennsylvania State University
207 Ferguson Bldg.
University Park, PA 16802
USA
Tel: 814-863-2095
Fax: 814-865-3725
cpf3@psu.edu
fisheries management; fisheries ecology; fisheries policy

PROGRAM PARTICIPANTS

Fleituch, Tadeusz M. lim
Institute of Freshwater Biology
Polish Academy of Sciences
ul. Slawkowska 17
Krakow 31-016
POLAND
Tel: 48-12-222115
Fax: 48-12-222115
fleituch@zbw.pau.krakow.pl
hydrobiology/ecology; freshwaters;
macroinvertebrate zoology

Fritz, Jennifer J. oce
Smithsonian Environmental Research Center
647 Contees Wharf Rd.
Edgewater, MD 21037
USA
Tel: 410-798-4424 ext 155
Fax: 301-261-7954
fritz@serc.si.edu
phytoplankton; physiology; ecology

Fussmann, Gregor lim
Ecotoxicology Department
Institute of Hydrobiology, TU Dresden
Dresden 01062
GERMANY
Tel: 49-351-463-2300
Fax: 49-351-463-7108
fussmann@rcs.urz.tu-dresden.de
plankton interactions; mesocosms; rotifers

Gao, Yu oce
AgBiotech Center
Rutgers University
Foran Hall, Dudley Rd.
New Brunswick, NJ 08903
USA
Tel: 908-932-8165, ext. 327
Fax: 908-932-0312
gao@aesop.rutgers.edu
biochemistry; physiology; molecular biology
primary production; DMSP production

Genovese, Salvatore J. oce
Ecology & Evolutionary Biology Department
Brown University
Box G-W
Providence, RI 02912
USA
Tel: 401-863-1395
Fax: 401-863-2166
Sal_Genovese@Brown.edu
marine benthic ecology; benthic-pelagic
coupling; hydrodynamics

George, Sunny lim
Research Section
Nelliyampathy Hills Conservation Society
Indian Natl.Trust for Art and Cultural
Heritage
NHCS, Padagiri P. O. Palakkad Dist.
Kerala 678509
INDIA
Tel: 91-492-346267
Fax: 91-484-222066
palicha@giasmd01.vsnl.net.in
conservation; taxonomy; toxicity

Gomez, Africa lim
Dept. Microbiologia i Ecologia
Universitat de Valencia
c/o Dr. Moliner 50
Burjasot (Valencia) E-46100
SPAIN
Tel: 346-386-4615
Fax: 346-386-4672
africa@uv.es or a.gomez@biosci.hull.ac.uk
rotifers; evolution; ecology

Gonzalez, Ernesto J. lim
Ecology Department
Central University of Venezuela - UCV
Apartado 47106 - Los Chaguaramos
Caracas, DF 1041
VENEZUELA
Tel: 58-2-7510111
Fax: 58-2-7535897
ergonza@reacciun.ve
primary production of phytoplankton;
phytoplankton-zooplankton interactions;
reservoir limnology

PROGRAM PARTICIPANTS

Gross, Elisabeth M. lim
Fakultaet fuer Biologie
University of Konstanz
Jacob-Burckhardt-Str. 25
D-78464 Konstanz
GERMANY
Tel: 49-7531-88-3105
Fax: 49-7531-88-4219
Elizabeth.Gross@uni-konstanz.de
chemical ecology; macrophytes; cyanobacteria; freshwater macrophyte herbivory

Grossart, Hans-Peter F. lim
MBRD
Scripps Institution of Oceanography
UC San Diego
9500 Gilman Drive
La Jolla, CA 92093-0202
USA
Tel: 619-534-3196
Fax: 619-534-7313
hgrossart@popmail.ucsd.edu
limnetic aggregates; microbial ecology; nutrient fluxes; sedimentation

Guan, RuiZhang lim
Aquaculture Department
Fisheries College
Jimei University
Xiamen, Fujian 361021
CHINA PR
Tel: 86-5926180973
Fax: 86-5926180476
rzguan@jmu.edu.cn
freshwater fisheries; aquatic biology and ecology; aquaculture

Gudkov, Dmitri I. lim
Department of Radioecology
Institute of Hydrobiology
Geroev Stalingrada Ave. 12
UA-254210 Kiev
UKRAINE
Tel: 380-44-418-91-83
Fax: 380-44 418-22-32
belyaev@madr.kiev.ua
radioecology; monitoring; tritium

Guo, Laodong oce
Oceanography Department
Texas A & M University
5007 Avenue U
Galveston, TX 77551
USA
Tel: 409-740-4772
Fax: 409-740-4786
guol@tamug.tamu.edu
dissolved organic carbon; colloids; isotopes

Hagerthey, Scot E. lim
Department of Biological Sciences
Michigan Technological University
1400 Townsend Dr.
Houghton, MI 49931
USA
Tel: 906-487-3084
Fax: 906-487-3167
sehagert@mtu.edu
groundwater-lake interactions; benthic algae; interspecific competition

Hamza, Waleed M. lim
Environmental Sciences Department
Faculty of Science
Alexandria University
21511 Alexandria
EGYPT
Tel: 20-3-549-4554
Fax: 20-3-483-6618-491-1794
hamza@alex.eun.eg
aquatic ecology; limnology; hydrobiology

Heil, Cynthia A. oce
Department of Botany
University of Queensland
Brisbane, Qd 4072
AUSTRALIA
Tel: 61-07-3365-7262
Fax: 61-07-3365-7321
C.Heil@botany.uq.edu.au
phytoplankton; blooms; geochemistry

Hentschel, Brian T. oce
Institute of Marine and Coastal Sciences
Rutgers University
71 Dudley Rd.
New Brunswick, NJ 08901-8521
USA
Tel: 732-932-6555, ext 372
Fax: 732-932-6520
hentsche@ahab.rutgers.edu
benthos; life histories; deposit feeding

PROGRAM PARTICIPANTS

Hofmann, Annette D. lim
Earth Sciences Department
F.-A. Forel Institute
University of Geneva
Institut F.-A. Forel, 10 route de Suisse
Versoix CH-1290
SWITZERLAND
Tel: 41-22-9509216
Fax: 41-22-7551342
annette.hofmann@terre.unige.ch
turbidimetry; particle transport in lakes; Fe & Mn biogeochemistry

Hope, Diane lim
Plant and Soil Science Department
University of Aberdeen
Cruickshank Building, St Machar Drive,
Aberdeen, Scotland AB24 3UU
UK
Tel: 44 -1224-273857
Fax: 44 -1224-272703
di.hope@abdn.ac.uk
riverine carbon fluxes; terrestrial-aquatic linkages; biogeochemical cycles

Horne, John K. oce
Great Lakes Environmental Research Laboratory
2205 Commonwealth Blvd.
Ann Arbor, MI 48104
USA
Tel: 313-741-2269
Fax: 313-741-2003
horne@glerl.noaa.gov
aquatic ecology; fisheries; predator-prey interactions

Johnson, Mark D. lim
Department of Life Sciences
University of New England
11 Hills Beach Road
Biddeford, ME 04005
USA
Tel: 207-282-0171 ext 2862
Fax: 207-282-6379
mjohnson@mailbox.une.edu
aquatic; microbial; ecology

Kaur, Parminder lim
Limnology Unit Department of Zoology
University of Delhi
c/o Dr. N.K. Mehra
Delhi 110007
INDIA
Tel: 91-11-5403237
Fax: 91-11-5405758
fmra123@ncmrwf.ernet.in attn: G.P.Singh
epiphyton; water quality; biodiversity

Kebede, Elizabeth lim
Life Sciences Department
University of East London
Romford Road
London E15 4LZ
UK
Tel: 44-0-181-5907000 ext.4551/52
Fax: 44-0-181-8493499
kebede@uel.ac.uk
phytoplankton ecology; tropical limnology; biogeochemistry

Khan, Muhammad I. lim
Institute of Pure and Applied Biology
Bahauddin Zakariya University
Multan, Punjab 60800
PAKISTAN
Tel: 92-61-220134
Fax: 92-61-220091
central@infolink.net.pk
microcosm; ecotoxicology; invertebrates

Kidd, Karen A. lim
Freshwater Institute
Department of Fisheries
501 University Crescent
Winnipeg, MB R3T 2N6
CANADA
Tel: 204-983-5226
Fax: 204-984-2404
kiddk@dfo-mpo.gc.ca
ecotoxicology; trophic interactions; stable isotopes

PROGRAM PARTICIPANTS

Kudela, Raphael M. oce
R&D Department
Monterey Bay Aquarium Research Institute
P.O. Box 628
Moss Landing, CA 95039-0628
USA
Tel: 408-775-1741
Fax: 408-775-1620
kura@mbari.org
new primary production; ocean optics; biological oceanography

Laird, Kathleen R. lim
Biology Department
Queen's University
Earl Hall
Kingston, ON K7L 3N6
CANADA
Tel: 613-545-6000, ext. 4088
Fax: 613-545-6617
lairdk@biology.queensu.ca
algal ecology; paleolimnology; climatic change

Leonardos, Ioannis lim
Fisheries Department of Etoloakarnania
Aristotle University of Thessaloniki, Greece
Par. Papoula 39
Mesolongi 30200
GREECE
Tel: 30-63128814
lagoon; fisheries; fish population dynamics

Lin, Senjie oce
Marine Sciences Research Center
State University of New York at Stony Brook
Stony Brook, NY 11794-5000
USA
Tel: 516-632-8697
Fax: 516-632-8820
selin@ccmail.sunysb.edu
phytoplankton; molecular; ecology

Lindell, Mans J. lim
Limnology Department
Lund University
Ecology Building
Lund 223 62
SWEDEN
Tel: 46-46-222-4080
Fax: 46-46-222-4003
Mans.Lindell@limnol.lu.se
UV-photochemistry; bacteria; DOM-degradation

Link, Jason S. lim
NOAA NMFS NEFSC
166 Water St.
Woods Hole, MA 02543
USA
Tel: 508-495-2340
Fax: 508-495-2258
jason.link@noaa.gov
jlink@whsun1.wh.whoi.edu
fish feeding dynamics; zooplankton-planktivore interactions; ecological modeling

Magorrian, Bridgeen H. oce
Department of Agriculture for Northern Ireland
Fisheries Division
Annex S, Castle Buildings
Stormont Estate
NORTHERN IRELAND
Tel: 44-1232-522395
bmagorrian@alpha1.dani.gov.uk
acoustic; benthos; fisheries

Mbagwu, Iheanyi G. lim
Limnology Department
Natl. Institute for Freshwater Fisheries Research
New Bussa
Niger State PMB 6006
NIGERIA
Tel: 234-032-670241
pollution; benthos; sediment

PROGRAM PARTICIPANTS

McCarthy, Sheryl A. oce
Oceanography Department
U.S. Department of State, Wash DC
8944 Miller Lane
Vienna, VA 22182
USA
Tel: 703-319-1690
Fax: 703-319-1690
smccar2410@aol.com
oceanography; ecology; invertebrates

McQuoid, Melissa R. oce
Centre for Earth and Ocean Research
University of Victoria
PO Box 3055
Victoria, BC V8W 3P6
CANADA
Tel: 250-472-4351
Fax: 250-721-6200
mcquoid@uvvm.uvic.ca
phytoplankton ecology; paleoceanography; diatom resting spores

Mead, Kristina S. oce
Integrative Biology Department
U.C. Berkeley
VLSB 3060
Berkeley, CA 94720-3140
USA
Tel: 510-643-9048
Fax: 510-643-6264
kmead@socrates.berkeley.edu
surf-zone; turbulence; fertilization; sensory ecology

Meyer-Harms, Bettina oce
Plymouth Marine Laboratory
Prospect Place
Plymouth
Devon, England PL1 3DH
UK
Tel: 44-1752-633101
BMH@wpo.nerc.ac.uk
copepods; selective feeding; HPLC

Moline, Mark A. oce
Biological Sciences Department - Rm 376
California Polytechnic State University
San Luis Obispo, CA 93407
USA
Tel: 805-756-2948
Fax: 805-756-1419
mmoline@calpoly.edu
phytoplankton; photophysiology; ecology

Moll, Andreas oce
Institut fuer Meereskunde
University of Hamburg
Troplowitzstr. 7
Hamburg 22529
GERMANY
Tel: 49-40-4123-2526
Fax: 49-40-560-5724
moll@ifm.uni-hamburg.de
ecological modelling; primary production; phosphorus cycle

Mumm, Heike lim
WBGU
Alfred Wegener Institute for Marine and Polar Research
P.O. Box 120161
Bremerhaven 27515
GERMANY
Tel: 49-471-4831-721
Fax: 49-471-4831-218
hmumm@awi-bremerhaven.de
zooplankton; invertebrate predation; biomanipulation

Nairn, Robert W. lim
School of Civil Engineering and Environmental Science
University of Oklahoma
202 West Boyd St., Room 334
Norman, OK 73019-0631
USA
Tel: 405-325-3354
Fax: 405-325-4217
nairn@mailhost.ecn.ou.edu
wetlands; biogeochemistry; aquatic ecology

PROGRAM PARTICIPANTS

O'Neil, Judith M. oce
School of Marine Science
University of Queensland
Brisbane, QLD 4072
AUSTRALIA
Tel: 61-7-3365-4132
Fax: 61-7-3365-7321
j.oneil@mailbox.uq.edu.au
Trichodesmium; N-cycling; plankton trophodynamics

Owen, Jeffrey S. lim
Agricultural Research Service
US Dept. of Agriculture
3450 SW Campus Way
Corvallis, OR 97331
USA
Tel: 541-750-8756
Fax: 541-750-8750
owenje@ucs.orst.edu
stable isotopes; nutrient cycling; biogeochemistry

Parsons, Michael L. oce
Louisiana Universities Marine Consortium
8124 Hwy. 56
Chauvin, LA 70344
USA
Tel: 504-851-2800
Fax: 504-851-2874
mparsons@lumcon.edu
diatoms; phytoplankton; paleoecology

Petrenko, Anne A. oce
Dept. of Earth Sciences
USC Ocean Physics Group
University Park
Los Angeles, CA 90089-0740
USA
Tel: 213-740-1971
Fax: 213-740-8801
petrenko@usc.edu
coastal; optics; wastewater

Pile, Adele J. oce
Marine Science Department
Harbor Branch Oceanographic Institution
5600 US 1 North
Fort Pierce, FL 34982
USA
Tel: 561-465-2400, ext 316
Fax: 561-468-0757
pile@hboi.edu
microbial food webs; benthic-pelagic coupling; physical-biological coupling

Pinheiro, Patricia R. de C. lim
Fishery Engineering
Universidade Federal do Ceara
Centro de Ciencias Agrarias
Departamento de Engenharia de Pesca
Caixa Postal 12168
Fortaleza, CE 60455-760
BRAZIL
Tel: 85-243-3981
Fax: 85-243-6321, 287-6940
pinheiro@taiba.ufc.br
nutrients; lakes; phosphorus

Puig, Alba lim
Limnology Department
National Institute of Natural Sciences
Av. Angel Gallardo 470
Buenos Aires 1405
ARGENTINA
Tel: 54-1-982-9410
Fax: 54-1-4494
albapuig@muanbe.gov.ar
zooplankton; ecology; reservoirs

Qureshi, Naureen A. oce
Centre of Excellence in Marine Biology
University of Karachi
Karachi 75270
PAKISTAN
Tel: 92-21-494-9968
naureen@qureshi.khi.erum.com.pk
zooplankton dynamics; benthic ecology; benthic pelagic coupling

PROGRAM PARTICIPANTS

Rhode, Stephan C. lim
Dept. of Neuroscience
School of Medicine
University of Pennsylvania
450 S. 43rd Street
Philadelphia, PA 19104
USA
Tel: 215-386-2490
Fax: 215-573-2015
bartos@mail.med.upenn.edu
global change; chemical communication; molecular ecology

Richardson, Tammi L. oce
Agricultural and Environmental Science Department
Queen's University of Belfast
Newforge Lane
Belfast BT9 5PX
N. IRELAND
Tel: 44-1232-255 500
Fax: 44-1232-382 244
T.Richardson@qub.ac.uk
phytoplankton; diatoms; nutrients

Roeck, Ute lim
Hydrology and Environment Department
Centre D'Analyses et de Recherches
76, Route du Rhin, BP24
Illkirch-Graffenstaden
Cedex 67401
FRANCE
Tel: 333-88-65-3737
Fax: 333-88-65-3738
ute.roeck.hydro-ulp@u-strasbg.fr
bioindication; mercury; hydrological functioning

Romero, Jose R. lim
Centre for Water Research
University of Western Australia
Nedlands, WA 6907
AUSTRALIA
Tel: 61-8-9380-1685
Fax: 61-8-9380-1015
romero@cwr.uwa.edu.au
stratification; mixing; modelling

Sala, Ma. Montserrat oce
Marine Biology Department
Instituto de Ciencias del Mar
Passeig Joan de Borbo s/n
Barcelona 08039
SPAIN
Tel: 34-3-2216416
Fax: 34-3-2217340
msala@cucafera.icm.csic.es
ectoenzyme; organic matter degradation: nutrient limitation

Sanyanga, Rudo A. lim
University Lake Kariba Research Station
P. O. Box 48
Kariba
ZIMBABWE
Tel: 263-61-22312, ext 2707
Fax: 263-61-2385
mandima@lkrs.uz.zw
fisheries; pollution; waste management

Schulz, Kimberly L. lim
Ecology, Evolution and Behavior Department
University of Minnesota
1987 Upper Buford Circle, Ecology Building
St. Paul, MN 55108
USA
Tel: 612-624-6297
Fax: 612-624-6777
schul098@tc.umn.edu
nutrient stoichiometry; invertebrate predation; bioenergetic modelling

Sell, Anne F. oce
Biology Department
Woods Hole Oceanographic Inst. MS # 33
Woods Hole, MA 02543
USA
Tel: 508-289-2524
Fax: 508-457-2169
asell@whoi.edu
zooplankton ecology; zooplankton physiology;
marine and freshwater zooplankton

PROGRAM PARTICIPANTS

Shang, Shaoling oce
Institute for Hydrospheric-Atmospheric Sciences
Nagoya University
Furo-cho, Chikusa-ku
Nagoya 464-01
JAPAN
Tel: 52-789-3490
Fax: 52-789-3436
shangsl@ihas.nagoya-u.ac.jp
biogeochemistry; modelling

Sharma, Subodh lim
Department of Biological Sciences
Kathmandu University
PO Box 6250
Kathmandu
NEPAL
Tel: 977-011-61399
Fax: 977-1-222761
ku@mos.com.np
water quality; biological assessment; index and scores

Shirenko, Larisa A. lim
Hydrobiology Department
Institute of Limnology
Russian Academy of Sciences
Sevastyanov Str. 9
St. Petersburg 196 199
RUSSIA
Tel: 7 -812-294-0260
Fax: 7-812-298-7327
larisa@lake.spb.su
biota; lakes; acidification

Slotina, Svetlana E. lim
Laboratory of Aquatic Ecotoxicology
Institute of Limnology
Russian Academy of Sciences
Sevastyanova Str. 9
St. Petersburg 196199
RUSSIA
Tel: 7-812-294-8009
Fax: 7-812-298-7327
slotina@lake.spb.su
aquatic biodegradation; hydrobionts; aquatic toxicology

Soranno, Patricia A. lim
Fisheries and Wildlife Department
Michigan State University
10A Natural Resources Building
East Lansing, MI 48824-1222
USA
Tel: 517-432-4330
Fax: 517-432-1699
soranno@pilot.msu.edu
ecosystem ecology; phosphorus cycling; zooplankton community dynamics

Subramaniam, Ajit oce
Chesapeake Biological Laboratory
P.O. Box 38
Solomons, MD 20688-0038
USA
Tel: 410-326-7201
Fax: 410-326-7341
ajit@wam.umd.edu
optical oceanography; biological oceanography; remote sensing

Sutheimer, Susan H. lim
Chemistry Department
Notre Dame College of Ohio
4545 College Road
Cleveland, OH 44121
USA
Tel: 216-381-1680
Fax: 216-381-3802
c.a.sutheimer@worldnet.att.net
metal; speciation; analysis

Sutherland, Terri-Ann F. oce
Martec Ltd.
Suite 400, 1888 Brunswick St.
Halifax, Nova Scotia B3T 3J8
CANADA
Tel: 902-426-7262
Fax: 902-426-4104
suthert@agc.bio.ns.ca
diatoms; biostabilization; sediment

PROGRAM PARTICIPANTS

Tank, Jennifer L. lim
Biology Department
Virginia Tech
2125 Derring, Biology Dept.
Blacksburg, VA 24061
USA
Tel: 540-231-8948
Fax: 540-231-9307
jtank@vt.edu
stream ecology; biofilms; nutrients

Thomas, Sabu lim
Science and Technology Department
Rajiv Gandhi Centre for Biotechnology
RGBT Jagathy
Trivandrum-14
Kerala State 695014
INDIA
Tel: 91-0471-329681
Fax: 91-0471-329472
aquatic biology; aquatic pollution;
hydrography

Twiss, Michael R. lim
Marine Chemistry and Geochemistry
Department
Woods Hole Oceanographic Institution
MS # 4, 360 Woods Hole Road
Woods Hole, MA 02543-1543
USA
Tel: 508-289-2641
Fax: 508-457-2164
mtwiss@whoi.edu
phytoplankton; trace metals; biogeochemistry

van Rooij, Jules M. oce
Centre for Limnology
Netherlands Institute of Ecology
Rijksstraatweg 6
Nieuwersluis 3631 AC
THE NETHERLANDS
Tel: 31-294-239352
Fax: 31-294-232224
rooij@cl.nioo.knaw.nl
fish biology; bioenergetics;
behavioural ecology

Venn, Cynthia oce
Geography and Earth Science Department
Bloomsburg University
116 Hartline Science Center
Bloomsburg, PA 17815
USA
Tel: 717-389-4141
Fax: 717-389-3028
cvenn@planetx.bloomu.edu
foraminiferida; marshes; ecology

Verschuren, Dirk lim
Large Lakes Observatory
University of Minnesota
2205 East 5th Street
Duluth, MN 55812
USA
Tel: 218-726-7654
Fax: 218-726-6979
verscoo1@tc.umn.edu
paleolimnology; tropical ecology;
invertebrate zoology

Voytek, Mary A. oce
Institute of Marine and Coastal Sciences
Rutgers University
P.O. Box 231, 15 Dudley Rd.
New Brunswick, NJ 08903
USA
Tel: 908-932-6555, ext 306
Fax: 908-932-6520
voytek@ahab.rutgers.edu
microbiology; biogeochemistry;
molecular ecology

Walia, Archana lim
Department of Zoology
University of Delhi
c/o British Council Division
17 Kasturba Gandhi Marg
Delhi 110001
INDIA
Tel: 91-3710111,3711401-2
Fax: 91-3710717
archana.walia@bc-
delhi.bcindia.xpgmx.in.sprint.com
environmental impact assessment;
toxicity; physico-chemical characterization

PROGRAM PARTICIPANTS

Wallace, William G. oce
Water Resouces Division
United States Geological Survey
345 Middlefield Road, MS 465
Menlo Park, CA 94025
USA
Tel: 415-329-4339
Fax: 415-329-4463
wwallace@usgs.gov
ecotoxicology; metal cycling; benthic ecology

Weinberg, Irina V lim
Laboratory of Biocenology
Limnological Institute
Russian Academy of Sciences
P. O. Box 4199
Irkutsk 664033
RUSSIA
Tel: 7-3952-466926
Fax: 7-095-4202106
root@lin.irkutsk.su
Lake Baikal; beaches; benthos

Weyhenmeyer, Gesa A. lim
Institute of Hydrology and Meteorology
TU Dresden, Wuerzburger Str. 46
Dresden 01187
GERMANY
Tel: 49-351-463-6379
Fax: 49-351-463-7162
Gesa.Weyhenmeyer@natgeog.uu.se
sediment resuspension; sediment traps; radionuclides

Wolfe, Alexander P. lim
Department of Geological Sciences & INSTAAR
University of Colorado
Campus Box 450
Boulder, CO 80309-0450
USA
Tel: 303-492-5326
Fax: 303-492-6388
wolfea@stripe.colorado.edu
paleolimnology; diatoms; arctic

Wolfstein, Kirsten lim
University of Kiel
Busum
Schleswig-Holstein 25761
GERMANY
Tel: 49-4834-604262
Fax: 49-48-3460-4299
Kwolf@ftz-west.uni-kiel.de
phytoplankton; settling, suspended, and particulate matter; microphytobenthos

Yager, Patricia L. oce
Department of Oceanography
Florida State University
Tallahassee, FL 32306-4320
USA
Tel: 850-644-5676
Fax: 850-644-2581
pyager@ocean.fsu.edu
high-latitude oceans; biogeochemistry; microbial ecology

Yamahira, Kazunori oce
Biology Department
Amakusa Marine Biological Laboratory
Tomioka, Reihoku-cho, Amakusa
Kumamoto Prefecture 863-25
JAPAN
Tel: 81-0969-35-0003
Tel: 81-0969-35-2413
kayamsca@mbox.nc.kyushu-u.ac.jp
selection; timing of spawning

Yee, Donald oce
Geology and Geophysics Department
University of Hawaii SOEST
Honolulu, HI 96822
USA
Tel: 808-956-2916
Fax: 808-956-7112
dono@soest.hawaii.edu
phytoplankton; trace metals; physiology

Zubina, Larisa V. lim
Limnological Institute
Russian Academy of Sciences
Ulan-Batorskaya ul., 3
Irkutsk 664033
RUSSIA
Tel: 7-3952-467695
Fax: 7-095-4202106
root@lin.irkutsk.su
Lake Baikal; fish; oogenesis

PROGRAM SPONSORS AND ORGANIZERS

PROGRAM SPONSORS

European Commission (EC)

Elisabeth Lipiatou
MAST Programme
European Commission
Directorate-General XII - Science Research and Development
Rue de la Loi 200
B-1040 Brussels
BELGIUM
Tel: 32-2-296-30-24
Fax: 32-2-295-12-42
Elisabeth.LIPIATOU@DG12.cec.be

National Aeronautics and Space Administration (NASA)

Janet W. Campbell
Ocean Biology/Biogeochemistry Program
MTPE/Code YS
NASA HQ
Washington, DC 20546
Tel: 202-358-0310
Fax: 202-358-3098
jcampbe1@mail.hq.nasa.gov

National Oceanic and Atmospheric Administration (NOAA)

Leon M. Cammen
National Seagrant College Program R/ORI
National Oceanic and Atmospheric Admin.
1335 East-West highway
Silver Spring, MD 20910
Tel: 301-713-2435
Fax: 301-713-0799
leon.cammen@noaa.gov

David L. Stein
Program Analysis and Development Group
NOAA/OAR R/PDC
1315 East West Highway Rm 11512
Silver Spring, MD 20912
Tel: 301-713-2465 x 118
Fax: 301-713-0158
davids@hq.oar.noaa.gov

National Science Foundation (NSF)

William Y.B. Chang
International Programs
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230
Tel: 703-306-1704
Fax: 703-306-0474
wychang@nsf.gov

Thomas M. Frost
Division of Environmental Biology
National Science Foundation
4201 Wilson Blvd., Arlington, VA 22230
Tel: 703-306-1479
Fax: 703-306-0367
tfrost@nsf.gov

Roberta L. Marinelli
Office of Polar Programs
National Science Foundation
4201 Wilson Blvd., Arlington, VA 22230
Tel: 703-306-1033
Fax: 703-306-0139
lduguay@nsf.gov

Phillip R. Taylor
Ocean Sciences Division
National Science Foundation
4201 Wilson Blvd., Arlington, VA 22230
Tel: 703-306-1587 x7211
Fax: 703-306-0390
prtaylor@nsf.gov

Office of Naval Research (ONR)

James E. Eckman
Biological & Chemical Oceanography Program
Code 322BC
Office of Naval Research
800 N. Quincy St.
Arlington, VA 22217
Tel: 703-696-4590
Fax: 703-696-3390
eckmanj@onr.navy.mil

Eric Eisenstadt
Molecular Biology Program
800 N. Quiincy St.
Arlington, VA 22217
Tel: 703-696-4596
Fax: 703-696-1212
eisense@onr.navy.mil

PROGRAM SPONSORS AND ORGANIZERS

PROGRAM ORGANIZERS

C. Susan Weiler
ASLO Office
Whitman College
Walla Walla, WA 99362
Tel: 509-527-5948
Fax: 509-527-5961
weiler@whitman.edu

Maarten Boersma
Max Planck Institute for Limnology
Postfach 165
D-24302 Ploen
GERMANY
Tel: 49-4522-763283
Fax: 49-4522-763310
boersma@mpil-ploen.mpg.de

AMERICAN SOCIETY OF LIMNOLOGY AND OCEANOGRAPHY (ASLO)

http://aslo.org/

Program Information
C. Susan Weiler, ASLO Executive Director
Tel: 509-527-5948
weiler@whitman.edu

Membership Information
ASLO Business Office
Tel: 800-929-ASLO or 254-399-9635
business@aslo.org